VOL. 11, No. 10 OCTOBER, 1934

The AMERICAN JOURNAL *of* OPTOMETRY

EDITORS

CAREL C. KOCH JACK I. KURTZ

COLLABORATORS

E. B. Alexander, *Duncan, Okla.*
J. Fred Andreae, *Baltimore, Md.*
J. O. Baxter, Sr., *New Bern, N. C.*
L. L. Beacher, *New York, N. Y.*
O. E. Bell, *Fairmount, W. Va.*
Robt. T. Best, *Fairmont, Minn.*
W. I. Brown, *New Bedford, Mass.*
J. T. Campbell, *Washington, N. C.*
R. G. Colberg, *Aberdeen, S. D.*
Paul Dill, *Greeley, Colo.*
H. C. Doane, *Boston, Mass.*
J. H. Drakeford, *New York, N. Y.*
G. L. DuPlessis, *Minneapolis, Minn.*
T. H. Eames, *W. Somerville, Mass.*
W. S. Farmer, *Oklahoma City, Okla.*
Wm. Feinbloom, *New York, N. Y.*
L. P. Folsom, *South Royalton, Vt.*
H. L. Fording, *Portland, Ore.*
F. W. Freeman, *Anderson, Ind.*
M. Gilbert, *Owosso, Mich.*
W. H. Glazer, *Philadelphia, Pa.*
R. M. Hall, *Cleveland, Ohio*
C. H. Hathaway, *Pontiac, Mich.*
C. K. Haynes, *Jamestown, N. Y.*
A. E. Hoare, *Los Angeles, Calif.*
B. T. Hoffman, *Chicago, Ill.*
H. S. Horton, *Cleveland, Ohio*
E. E. Hotaling, *New York, N. Y.*
C. E. Jaeckle, *Newark, N. J.*
Chester Johnson, *Philadelphia, Pa.*
H. D. Judd, *Detroit, Mich.*
B. E. Kehl, *St. Louis, Mo.*
L. H. Kraskin, *Washington, D. C.*
N. Levin, *Chelsea, Mass.*
R. E. Littlefield, *Kansas City, Mo.*
J. J. Livingston, *Little Rock, Ark.*
C. V. Lyons, *San Francisco, Calif.*
G. A. MacElree, Jr., *Phila., Pa.*
F. L. Mason, *Berkley, Calif.*
D. J. Mayer, *Riverside, Calif.*
O. L. McCulloch, *Holyoke, Mass.*
Wm. Mendelsohn, *Chicago, Ill.*
F. McFadden, *Rutland, Vt.*
O. J. Melvin, *Omaha, Nebr.*
M. B. Meyer, *Wilmington, Del.*
J. K. Morris, *Erie, Pa.*
J. C. Neill, *Philadelphia, Pa.*
J. Neumueller, *Philadelphia, Pa.*
M. M. Ocshier, *W. Springfield, Pa.*
G. Oertel, *Syracuse, N. Y.*
G. O. Ohlsson, *Detroit, Mich.*
C. R. Padelford, *Fall River, Mass.*
D. R. Paine, *Topeka, Kan.*
Geo. A. Parkins, *Ord, Nebr.*
J. I. Pascal, *New York, N. Y.*
R. J. Pearce, *Greensboro, N. C.*
R. M. Peckham, *Rochester, N. Y.*
Ernest Petry, *Rochester, N. Y.*
S. H. Robinson, *Prescott, Ariz.*
A. N. Prussin, *Detroit, Mich.*
E. LeRoy Ryer, *New York, N. Y.*
H. L. Salov, *Newark, N. J.*
Charles Sheard, *Rochester, Minn.*
Carl Shephard, *Chicago, Ill.*
R. E. Simpson, *Pasadena, Calif.*
W. Smith, *Dorchester, Mass.*
H. R. Spitler, *Eaton, Ohio*
M. J. Stark, *Union City, N. J.*
M. Steinfeld, *Paducah, Ky.*
Edwin Forbes Tait, *Phila., Pa.*
H. Thomas, *Wenatchee, Wash.*
S. S. Titus, *Kansas City, Mo.*
R. N. Walker, *Winston-Salem, N. C.*
A. P. Wheelock, *Des Moines, Iowa*
A. C. Whitaker, Jr., *Bridgeton, N. J.*
E. G. Wiseman, *Buffalo, N. Y.*
A. T. Wray, *Los Angeles, Calif.*
L. K. Wyatt, *Peoria, Ill.*

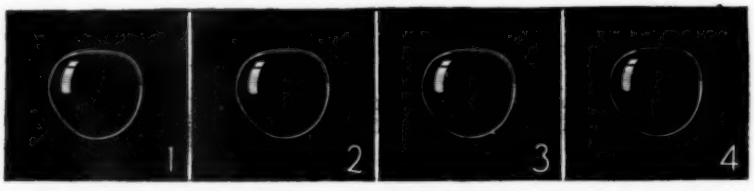
Published Monthly by the American Journal of Optometry Publishing Association,
1501 Foshay Tower, 821 Marquette Ave., Minneapolis, Minn.

ANNUAL SUBSCRIPTION $4.00. CANADA AND FOREIGN $5.00

Entered as second-class matter February 20, 1924, at the postoffice at Minneapolis, Minnesota, under the Act of March 3, 1879.

GLARE CONSCIOUS?

We are becoming increasingly aware of the harmful effects of "too much light." Lighting engineers today are devoting considerable time and thought to the problem of controlling "overbrightness" or glare in artificial lighting. This is a step in the right direction but not the complete solution by any means . . . Glare is everywhere. Indoors, outdoors, at work and at play, our eyes are assailed by that uncomfortable, fatiguing over-brightness that we know as glare. For complete patient comfort prescribe Soft-Lites, the absorptive lenses that reduce light evenly and uniformly for easy, effortless seeing.



For constant wear. It provides comfortable vision without glare-strain. For eyes sensitive to mild forms of glare. Pleasing appearance.

For constant wear. It provides a slight increase of light absorption over No. 1 shade. For eyes supersensitive to glare. Inconspicuous.

This shade is for occasional wear. It provides protection from outdoor glare as found in motoring, golfing, tennis and other outdoor sports.

For occasional wear. It provides protection from intense outdoor glare as at the beach, fishing, boating, or in semi-tropical areas.

AN ADVERTISEMENT OF THE SOFT-LITE LENS CO., Inc.

AMERICAN JOURNAL OF OPTOMETRY

Vol. 11 OCTOBER, 1934 No. 10

CONTENTS

PAGE

ORIGINAL PAPERS

The Prescription of Prisms as determined by analysis of data on relative amplitudes of convergence and accommodation. Charles Sheard 364

Astigmatic Accommodation. B. M. Lazich 379

A Five Outlet Rheostat. F. McFadden 384

The Clinical significance of differences in the relative size and shape of Ocular Images. Howard C. Doane 390

EDITORIALS

Hygiene of Illumination 401

Graduate Optometric Education 403

Ocular Symptoms of Ear, Nose and Throat Involvements 404

Bifocal Selection Chart

It has been found that no one bifocal will successfully fit every type of refractive error. With this fact in mind we have prepared the Waltex Bifocal Selection Chart. The use of this chart will result in more comfortable bifocals being fitted.

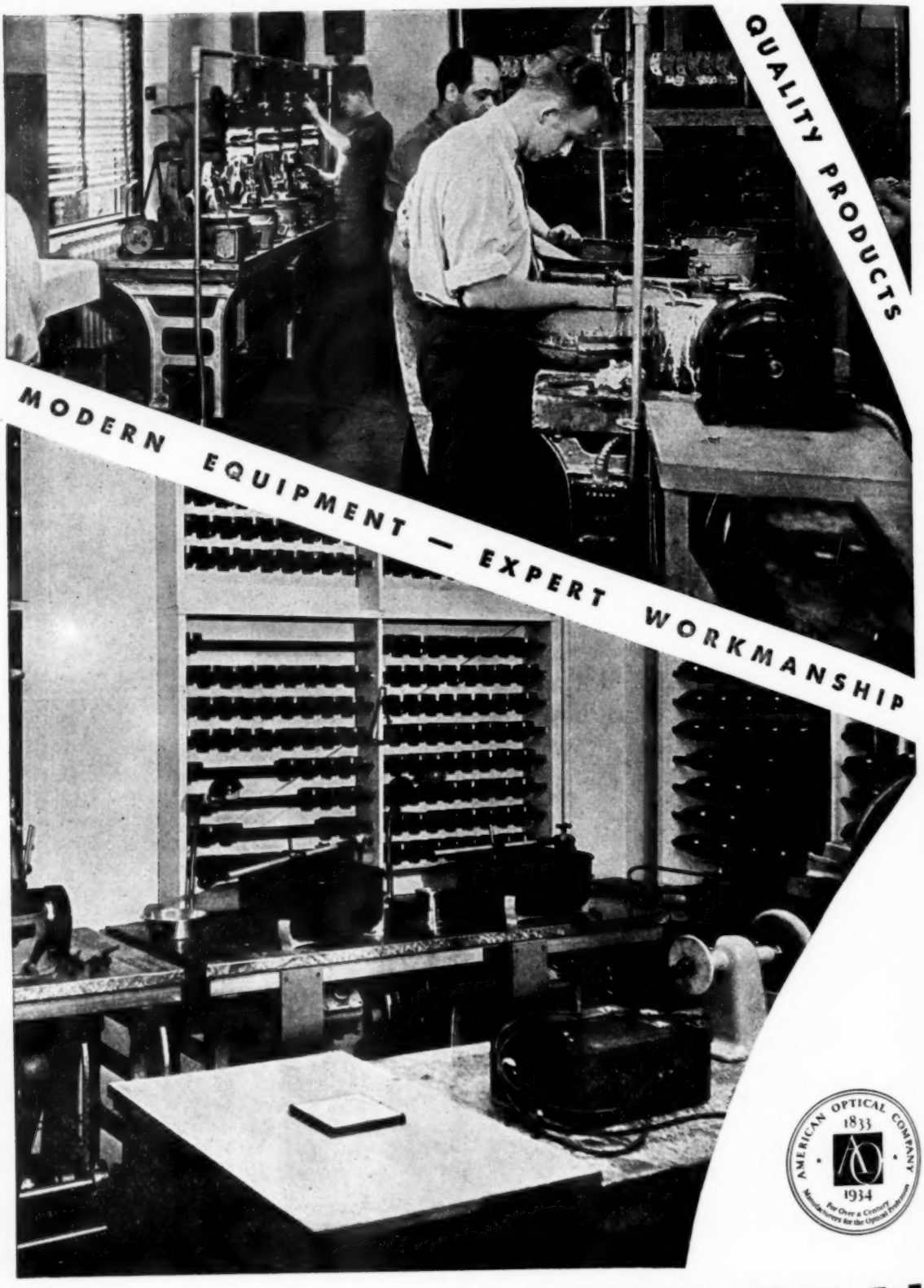
Write and we will gladly forward complete details.

THE WALMAN OPTICAL CO.

MINNEAPOLIS

ST. PAUL GRAND FORKS

AMERICAN OPTICAL



AMERICAN

AMERICAN JOURNAL OF OPTOMETRY

Vol. 11 OCTOBER, 1934 No. 10

THE PRESCRIPTION OF PRISMS

As Determined by Analyses of Data on Relative Amplitudes of Convergence and Accommodation*

Charles Sheard, Ph.D., Sc.D.
Division of Physics and Biophysical Research, The Mayo Foundation, Rochester, Minnesota

Asthenopia

Asthenopia, the symptoms of which are not relieved by the correction of errors of refraction alone, is encountered frequently enough to warrant a thorough discussion of ways and means of obtaining ocular data which may be of value as diagnostic aids and as suggestions regarding possible subsequent treatment. There are persons, commonly said to be of the neurotic type, who experience ocular discomfort and who, even after numerous examinations covering a period of years, fail to receive relief. Small and apparently trifling changes have been made in the dioptric strengths of the glasses prescribed; the axes of the cylinders have been shifted slightly; possibly some one may have been bold enough to add small amounts of prisms with directions of their bases as may have suited his fancy. But in spite of it all, the symptoms of which the patients complain continue and, as Percival[a] stated: "Finally, in despair, they abandon the spectacles which they cannot wear with comfort and seek relief in the last new drug advertised to cure headaches."

Is the asthenopia due to constitutional defects, or is it due to some local ocular cause lying in excessive demands either on the ciliary muscles, in their efforts to maintain correct accommodative action and hence distinct vision, or on the extra-ocular muscles, in their endeavors to maintain binocular single vision; or, perchance, is it due to a combination of both accommodative and fusional demands coupled with low functional reserves? Both constitutional and local ocular conditions are factors. It must be admitted that errors of refraction or muscular imbalances that would be insufficient to produce discomfort when elements of both bodily

*Submitted for publication August 24, 1934.

and ocular functional strength exist are capable of producing discomfort and other symptoms that may seem to be out of proportion to the amount of refractive or muscular error when bodily weakness exists. It seems to me that those who practice in any wise on the human body frequently fail to appreciate the fact that symptoms of discomfort, as well as untoward effects produced by causes such as focal infection, are somewhat in proportion to the absence of a state of well-being and depend on the character of occupation, mental outlook, and habits, as well as on the elements of weakness and strength which reside in the functions of the part of the body to which the discomfort is attributed. In brief, when functions are in strength and possess ample reserves, they are capable of meeting demands or of offsetting deficits which would be impossible, at least without inefficiency and discomfort, when these functions are in weakness.

Relationships Between Accommodation and Convergence

In conditions of ocular discomfort which are not relieved by spherical or cylindrical lenses, or by combinations of them, attention should be directed to the relationships between convergence and accommodation. Many years ago Donders, in his classic treatise, first drew attention to these relationships. In the last three-quarters of a century many contributions have been made regarding the significance of data on the accommodative and convergence resources, their dependence and their independence (Landolt, Stevens, Maddox, Savage, Howe, and others). Data regarding the relative ranges of positive and negative accommodation for any given degrees of convergence, and the relative divergences and convergences with various amounts of accommodative action, indicate that there is considerable independence of these functions. In most cases, then, the relation between convergence and accommodation can be altered considerably to meet the different requirements which the individual may experience from the standpoint of distinct and of single vision. However, conditions do arise in which the relative ranges of convergence and accommodation clearly indicate that distinct and single vision cannot be maintained with comfort. Discomfort, to be sure, is noted frequently when glasses are first worn; doubtless this is due to the new coordination or readjustments of convergence and accommodation, for the discomfort shortly disappears. It it not such temporary discomfort that I am considering, but rather the persistent type which does not lend itself readily to alleviation and in which there is some difficulty that prevents the proper adaptation and correlation of convergence and accommodation.

A number of diopters of accommodation can be elicited or suppressed by the use of concave or convex spherical lenses, respectively; a number of degrees or prism diopters of convergence or divergence can be induced through the use of prisms placed with bases out and in, respectively. These data, when plotted, give curves of the type shown in figure 1, which I have selected from those presented by Percival[7] for reasons which will be evident shortly. The curve PBA shows the positive relative accom-

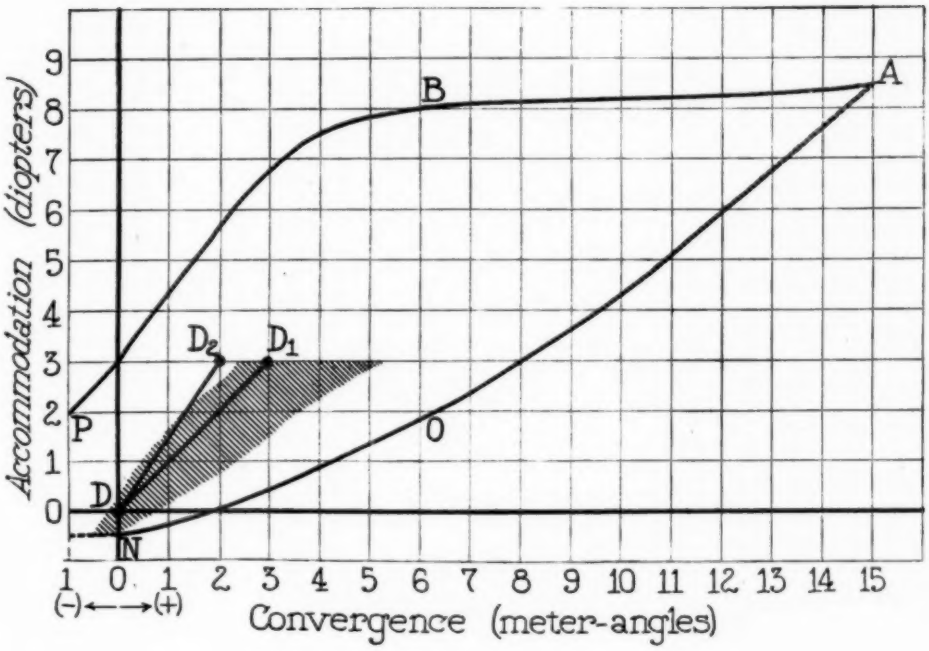


FIGURE 1

modation obtained through the use of concave lenses for various meter-angles of convergence, and also the values of the relative negative convergence (relative divergence or abduction) obtained through the use of prisms, base in, for corresponding diopters of accommodation demanded at various fixation distances. The curve NOA represents the negative relative amplitudes of accommodation obtained through the use of convex lenses for like conditions of convergence, and also the relative positive convergence or adduction obtained through the use of prisms, base out, for various diopters of accommodation. A glance at the curves shows that the person under test exhibited a maximum of convergence of 15 meter-angles and a maximum of accommodation of 8.5 diopters which, when added to the 0.5 diopters of hyperopia, as indicated at the point N, represents 9 diopters of accommodation. The horizontal line gives the relative convergence for each diopter of accommodation (indicated on the vertical line) exerted or suppressed. Thus, at the point marked 4 (actually indicating 4.5 diopters of accommodation), the range of convergence was from 0.75 to 9.5 meter-angles; at 7.5 diopters, the range of convergence was from 4 meter-angles to 13.5 meter-angles. In a similar manner the range of accommodation under a specified amount of convergence is indicated by the vertical lines. Thus, when exerting 5 meter-angles of convergence, the range of accommodation is denoted by the vertical line from 8.5 diopters (8 diopters plus 0.5 diopter of hyper-

opia) to 1.5 diopters. It is obvious, therefore, that the amount of convergence that can be exercised is somewhat dependent on the amount of accommodation that is exerted at the same time. Also it is apparent that these relationships of accommodation and convergence will vary greatly with refractive errors and with the resources of accommodation and convergence of the person under test.

Curves such as those shown in figure 1 contain a complete survey of the dependence and independence of the functions of accommodation and convergence. Data regarding the positive and negative relative accommodations and the positive and negative relative convergences are readily obtained from the plotted data. I[9,10] have contended for a number of years that the data regarding the absolute ranges of accommodation and of convergence are of little value as compared to information regarding the *relative* ranges of convergence, and that limitations in relative accommodation, relative convergence, or both, are the prime factors in ocular discomfort. As shown in figure 1, the person under test, with 3 meter-angles of convergence demanded and delivered (hence fixing a point 33.3 cm. from the eyes), has a positive relative accommodation of 4 diopters and a negative relative accommodation of 2.5 diopters, and a positive relative convergence, or positive fusional reserve, of 5 meter-angles and a negative relative convergence of 3 meter-angles. These data indicate that distinct, binocular single vision can be obtained and maintained with considerable variation in the functioning of the extra-ocular muscles, as evidenced by prisms with bases in or out, and of the ciliary muscle, as evidenced by plus and minus lenses.

The line DD_1 (fig. 1) is the locus of points in which the accommodation, in diopters, and the convergence, in meter-angles, have the same value. With no accommodation, there is no convergence: with 3 diopters of accommodation there are 3 meter-angles of convergence. If, under dissociation tests, such conditions should be found to exist, the conclusion would be warranted that all of the convergence necessary for binocular single vision at any point was in accompaniment with the act of accommodation. Whether or not such a condition exists is determined by dissociation tests (as with 6 prism diopters, base up or down, before one eye), the person under test reading or endeavoring to read at the distance of test. I believe it has been demonstrated that, at the usual reading distance of about 33 cm., there is normally an exophoria of 4 to 6 prism diopters[11,15]. As a result, therefore, in the normal physiologic relationships between accommodation and convergence at the ordinary reading distance, about two-thirds of the necessary convergence comes in association with the act of accommodation and the remaining third through fusional sources. Hence, in figure 1, the line DD_1 would start at the zero point, but, instead of running at an angle of 45°, it would occupy an angular position of practically 35° with reference to the Y axis (accommodation), as shown at DD_2. This point should be noted and borne in mind, since conclusions as to the necessity for prisms will

depend, in part, at least, on which position of the line (DD_1 or DD_2) is taken as a standard.

Absolute Versus Relative Convergence

Many authorities have taken the absolute range of convergence as a foundation on which to base judgment regarding the probable role which extra-ocular innervational weakness plays in discomfort and the necessity for the use of prismatic relief. Landolt made the suggestion that not more than one-third of the absolute range of convergence can be exercised continuously without fatigue. It appears much more logical in theory, and is apparently substantiated in practice, to state that the basis of relief for extra-ocular imbalances must depend on the relative range rather than the absolute range of convergence. For that part of the absolute range which is beyond the relative portion, for any given amount of accommodation, cannot possibly be brought into action and therefore must be excluded.

Some years ago I[9,10] proposed that, as a general rule, not more than a half to a third of the relative positive or negative convergence, depending on whether the muscular imbalance was a condition of exophoria or esophoria, could be used continuously without producing fatigue and other untoward symptoms generally classed under the term, discomfort. I believed that it was possible to draw conclusions regarding the possibility of binocular single vision and whether or not binocular single vision could be obtained with comfort. But, initially, the extra-ocular imbalance at the point of fixation, and hence the *amount of the demand* on the functions of convergence to maintain binocular single vision, must be found. Furthermore, it would be necessary to know the values of the relative convergence (adduction and abduction), or positive reserve and negative reserve convergences, thereby obtaining information regarding the *total powers of innervation* of the recti muscles and the *fusional reserves*. As a routine procedure, therefore, data must be obtained both with and without lenses correcting the refractive errors. These data must bear on the following: (1) the demands on the ciliary and extra-ocular muscles and (2) the accommodative and fusional reserves at the two points of fixation, namely, at 6 meters and at the usual reading distance of approximately 33 cm. In other words, after finding the extra-ocular imbalance at the point of fixation, thereby obtaining the amount of the demand on the convergence functions to maintain binocular single vision, and after getting the values of the relative convergence (adduction and abduction or, in other terms, positive reserve and negative reserve convergences), thereby obtaining information regarding the total innervational powers of the recti muscles and the fusional reserves, it is possible to draw conclusions regarding the possibility of binocular single vision and whether or not binocular single vision can be obtained with comfort.

Percival,[6,7] in writing on the relation of convergence to accommodation and its practical bearing, states that for various reasons he omits all tests with Maddox rod, Maddox double prism, or similar dissociating

devices for finding the amount of imbalance exhibited by the extra-ocular muscles. He lays particular emphasis, however, on the relationship between the position of the diagonal line of equal accommodation-convergence and the limits of the positive and negative relative convergences, with fixation at 6 meters and at the normal reading distance. In the matter of the value of the tests of tonicity at distant and near points, I believe that the weight of evidence, as well as of actual practice, is against the view of Percival.

In obtaining the breadth of fusion, either at 6 meters or at 33 cm., the patient should fix his attention on the smallest letter that he can see at a distance of 6 meters, or on the ruled line or vertical row of small letters at the reading distance. Then, as prisms are placed before the eye, he should report as soon as the letters or the lines begin to be blurred or indistinct. By this procedure constancy of the amount of accommodation involved for the given distance of fixation is assured. If the patient is allowed to exercise his accommodation, a much greater amount of convergence is often possible. In all tests the patient is to wear the lenses which correct refractive errors and, at the reading distance, such lenses as compensate for the presbyopic condition, if this is present.

Area of Comfort

So far as I know, Percival was the originator of the expression, "area of comfort." In his paper of 1892 he wrote: "I think we may assume, tentatively, as a working hypothesis that the area of comfort occupies about the middle third of the relative range of convergence between the limits corresponding to an exertion of zero diopter and 3 diopters of accommodation. I have defined the limits in this way from a careful examination of my notes and charts, assuming that when a prism gives relief it brings the diagonal (the line graphically showing the mathematic relationship between accommodation and convergence; that is to say, the same number of diopters of accommodation as meter-angles of convergence)* within the area of comfort." In his book, "The prescribing of spectacles," he wrote: "From a careful examination of the notes and charts that I have taken of different patients, I have come to the conclusion that this area occupies about the middle third of the relative ranges between the limts of 0 and 3 m. a. of convergence. Above 3 m. a. this definition does not hold good . . . Whenever I have found the diagonal (0 to 3) to lie outside this area of comfort, I have heard complaints of asthenopia."

By way of discussion, Percival wrote: "The method that I have just given is not that usually recommended; it is customary to measure the absolute range of convergence and then consider that not more than one-third of this total range can be exercised continuously without fatigue. This sounds a simple rule; . . . there are very great difficulties in finding the total range. Further, I consider the rule illogical, as the

*Material within this parentheses is mine—Author.

amount of convergence that can be exercised depends entirely upon the amount of accommodation that is exerted at that time. In fact, it must be the relative, not the absolute, range that should be considered. I admit that my rule is empirical, and that some patients may require rather more than one-third of their relative range to enter into the calculations, but I have found the method exceedingly useful in practice."

Weymouth, Brust and Gobar, in their paper, "Ocular muscle balance at the reading distance and other related factors," commented: "Percival's (1892) conception of an 'area of comfort' occupying the middle third of the zone of relative accommodation and convergence is, we consider, a very valuable one, and our figures are in accord with the main features of this."

Illustrating the Application of the Area of Comfort

As illustrating the conceptions of "area of comfort" and their applications in routine refraction, I am including data and the accompanying figure 2 (from Percival[7]) regarding a "Mrs. F., a neurotic emmetrope, age 25, who suffered from asthenopia that was found to be due to an abnormal relative range of convergence. Her chart (fig. 2) shows that, with her accommodation relaxed, she could diverge two meter-angles and could also just maintain parallelism. When 3 diopters of accommodation was exerted her range of convergence was from —0.5 meter-angles to +4.0 meter-angles. The diagonal was about 0.5 meter-angles on the positive side of her area of comfort. She had been given +1 diopter glasses for reading, which only aggravated her difficulty. This can be easily seen from the chart as the +1 diopter lenses would practically lower the zero horizontal line and the diagonal one step, so that when exercising two diopters of accommodation she would have to exert her utmost limit of convergence to see at one-third meter. Clearly —1 diopter would have been much more serviceable. I ordered her simple abducting prisms (—1° prism)* for constant use. These have been quite satisfactory in relieving her of pain and what is perhaps better evidence of their benefit, the puffiness of the lids and the conjunctivitis have disappeared and show no tendency to recur. The abducting prisms ordered just brought the diagonal within the shaded area of comfort."

Figure 2 affords data not only of academic interest, but also of much practical value. With a divergence of 2 meter-angles the person under test could develop 2 diopters of accommodation. With visual axes parallel she could get about 3.5 diopters of accommodation as a maximum, with a negative relative accommodation, found by the use of convex lenses, of zero within the range of 0 to —2 meter-angles of convergence. Such data, which are found frequently enough, do not argue for the general use of prisms, base in, as a means of disclosing greater hyperopia (latency) or less myopia (spasm of accommodation), and do not support the idea of the prevalence of a so-called convergence-accom-

*Practically O.U. 2 prism diopters, base in.

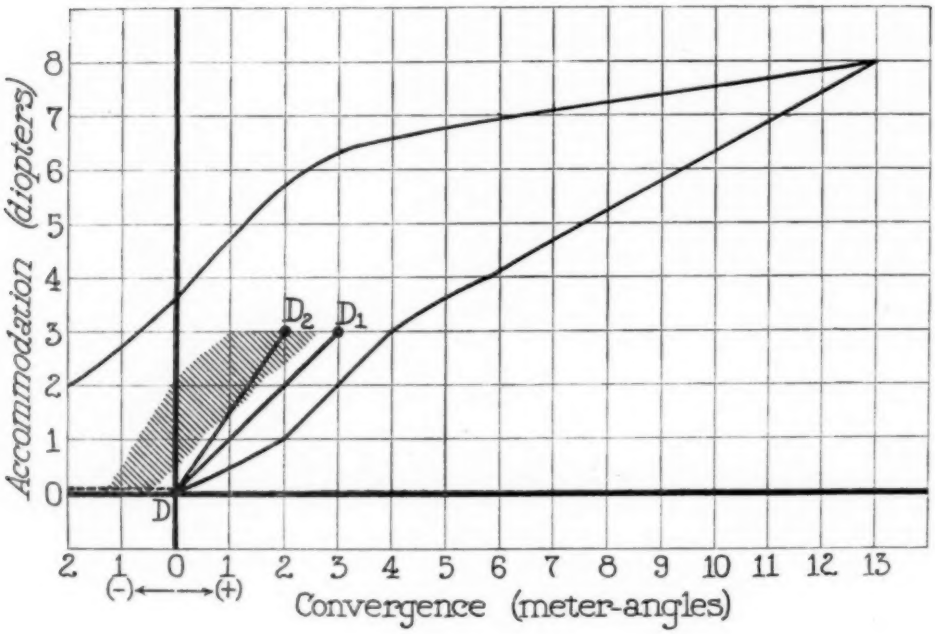


FIGURE 2

modation, although this condition may exist. Furthermore, with fixation at 33 cm. the positive amplitude of accommodation is satisfactory, but the minimal accommodation, or the amount of plus lenticular power that the eyes will accept, is about 1 diopter. In normal conditions, as shown in figure 1, the amount of convex lens power that can be added when fixation is 33 cm. amounts to 2.5 diopters, whereas the maximal accommodation is 7 diopters. Insofar as the breadth of fusion is concerned, the chart (fig. 2) shows that the total range of convergence with 3 diopters of accommodation in force is 5 meter-angles, of which 4 meter-angles are negative and 1 meter-angle is positive convergence. This is outside of the normal ratio. Percival is correct, therefore, in asserting that prisms, base in, are called for in order to shift the diagonal to the left or, in other words, in order to relieve the inadequate function of positive convergence by allowing the eyes to assume a position of greater divergence, which is compensated optically through the use of prisms, base in. Still this is not the natural position of balance, which is considerably divergent.

However, it is a better procedure, I believe, to find the extra-ocular muscle imbalance at the reading point (33 cm.) using a test object, such as a line of type on a card, which demands an accommodative change of 3 diopters, although a greater or lesser amount of innervation may be actually demanded in order to produce the dioptric change. Then the

values of the positive and negative fusional reserve may be obtained, using a vertical row of letters printed on a suitable card. From such data, accepting the principle that the demand on any given function of convergence, whether it be positive or negative, must not exceed a half to a third of the fusion reserve, prisms of an amount sufficient to enable the act of binocular single vision to take place comfortably may be prescribed. In a general way, it is true that the procedures advocated either by Percival or by me will lead to comparable conclusions in practical routine anomalies of the motility of the eyes. In any event, both procedures will work toward the economical and efficient coördination of the ocular functions, and this means comfort.

Fields of Accommodation and Convergence

Except in rare cases, or in an academic study, too much time is consumed and it is too arduous a task to get the full data on the relationships between accommodation and convergence, as evidenced by the positive and negative relative amplitudes of accommodation and convergence, for a variety of points of fixation from 6 meters to the punctum proximum of convergence or the point of maximal convergence; that is, the closest point of approach to the eyes at which binocular single vision persists. As a matter of ordinary refractive routine it is necessary only to get data at two points of fixation, namely, at 6 meters at 33.3 cm., since the relative ranges of accommodation and convergence at these two points furnish adequate information regarding the asthenic or sthenic conditions. The routine of procedure may be summarized in these statements:

1. Correct all errors of refraction and any vertical imbalances before making tests on the relative amplitudes of accommodation and convergence.

2. Determine the relative ranges of convergence with no manifest accommodation by means of abducting and adducting prisms, the test object being at a distance of not less than 6 meters.

3. Determine the relative positive and negative amplitudes of accommodation through the use of concave and convex lenses. At 6 meters, there should be no negative amplitude of accommodation; if there is, then there is evidence of undercorrection of hyperopia or overcorrection of myopia.

4. Determine the positive and negative amplitudes of convergence with definite and distinct fixation at the 33.3 cm. distance.

5. Determine the relative positive and negative amplitudes of accommodation at the 33.3 cm. point.

6. Determine the absolute maximum of convergence, the closest point of approach to the eyes at which binocular single vision is maintained, in order to find out if the range of convergence is about normal or is restricted considerably.

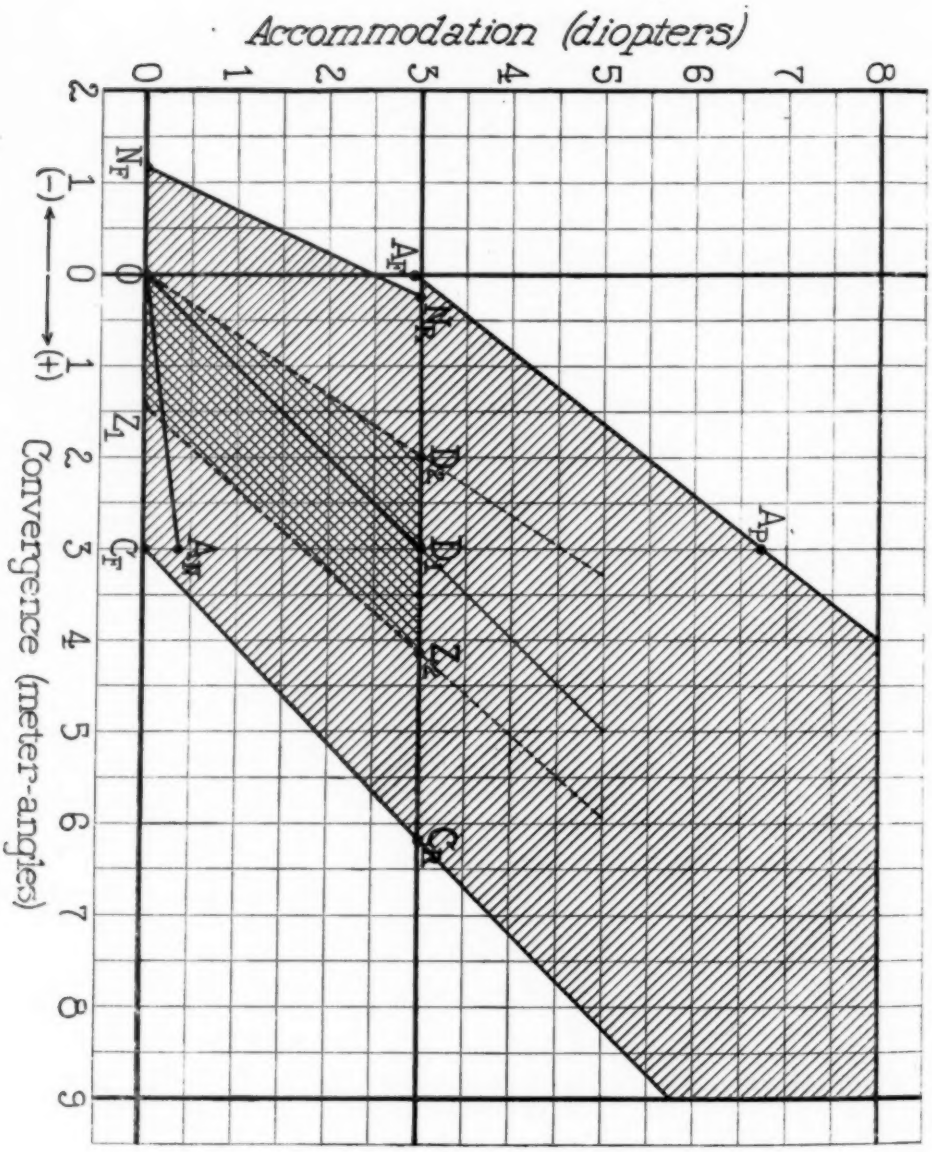


FIGURE 3

Figure 3 illustrates the manner in which data, which are obtainable by procedures I have outlined, may be plotted and from which the examiner may determine quickly and accurately the strength or weakness of either accommodation or convergence as well as the inter-relationships between these functions controlling distinct and single binocular vision.

The data plotted in figure 3 are representative of a normal, or standard, pair of eyes for a person twenty to twenty-five years of age and show adequate relative amplitudes of accommodation, no extra-ocular muscular imbalances (orthophoria) at the 6 meter point of fixation, 5 prism diopters of exophoria at the 33 cm. point of fixation, and ample positive and negative fusion reserves. The shaded area, therefore, represents that which may be termed the zone of relative accommodation and relative convergence. The area of comfort, as denoted by Percival, is shown by cross-hatching as O D_2 Z_2 Z_1 with respect to two points of test, 6 meters and 33 cm. The line OD_1, which represents equal accommodation and convergence, lies well within this area, whereas the line OD_2, which indicates orthophoria at 6 meters and 6 prism diopters of exophoria at 33 cm., practically constitutes one of the boundary lines of this area.

It will be found conducive to accuracy of diagnosis and a valuable guide to subsequent treatment if those interested in these matters will have printed, in considerable quantity, a chart such as that shown in figure 3, of a size, for example, 5 by 8 or 4 by 6 inches, which can be filed with the history of the case and other data obtained during ocular testing. These cards should be printed in black ink and the data acquired in the examination of any pair of eyes should be recorded on the charts in red ink. In this manner a full pictorial record is at hand and the data thus plotted may be compared immediately with those which may be considered reasonably standard or normal.

Prismatic Corrections from the Standpoint of the Area of Comfort

The data having been obtained on the relative positive and negative ranges of accommodation and convergence for two points of fixation, 6 meters and 1/3 meter, prisms for purposes of inducing immediate comfort are prescribed, in accordance with the conception of the area of comfort, as follows:

1. Esophoria: *Min.* + 1/3 R. C.
2. Exophoria: *Max.* — 1/3 R. C.

The symbols *Min.* and *Max.* are to be understood as meaning the relative minimum and relative maximum of convergence found at the distance for which the tests were made or for which the lenses prescribed are to be used. The symbol *R. C.* is the range of convergence for each eye, and is therefore one-half of the total range of convergence, or one-half of the sum of the abduction and adduction for the given point of fixation. Since we are accustomed to use the terms abduction and adduction instead of relative minimum and relative maximum of convergence, we may write the expressions for determining the amount of prism to be prescribed in the form:

3. Esophoria: Abd. + 1/3 R. C.
4. Exophoria: Add. — 1/3 R. C.

Illustrations

Relative range of convergence at 6 meters.—In a given case, suppose the abduction to be 6 △ and the abduction to be 12 △. The total rel-

ative range (T. R.) is 18 △. In reading the literature, especially the writings of Percival ("The prescribing of spectacles"), it is better to consider the range of convergence (R. C.) for each eye, which is, in this instance, 18/2 or 9 △. Mathematically, then, the area of comfort lies, for each eye, between zero and 3 △ of positive convergence. The ideal situation, from this standpoint, is that in which the eyes are at rest at that portion of the region of ocular comfort (the middle third of the relative range of convergence) which the more closely approximates the condition of orthophoria; or, mathematically expressed, the condition in which no accommodation and no convergence are exercised. In this instance, therefore:

$$\text{Abd.} + 1/3 \text{ R. C.} = -6 + 18/3 = 0,$$

hence no prisms would be incorporated, as the situation is an ideal one from the standpoint under consideration.

Again, if the R. C. for each eye extended from 1 △ base in (— 1 △) to 5 △, base out, (+ 5 △), then the indicated prismatic correction to give comfort at once, or assist in producing it, would be O. U. 1 △, base out. This may be calculated from:

$$\text{Abd.} + 1/3 \text{ R. C.} = -1 + 6/3 = 1.$$

Or again, if the R. C. for each eye should range between 7 △, base in, and 2 △, base out, the indicated prismatic correction would be:

$$\text{Add.} - 1/3 \text{ R. C.} = 2 - 9/3 = -1,$$

indicating the incorporation of O. U. 1 △, base in.

In executing these tests, the subject under examination should fix his attention on the smallest letter he can see at 6 meters' distance and state when the letter becomes indistinct or double. Should the patient exercise his accommodation when obtaining the abduction, for example, the amount of convergence will probably be greater.

Relative range of convergence at the reading distance.—With the ruled line or row of letters as a test object, the person under examination should state the moment the line or letters appear blurred, in order that no more than the due amount of accommodation be exerted. The reading correction, if any, is to be worn.

If the abduction is 2 △ and the adduction is 10 △ for each eye, then the R. C. is 12 prism diopters. The convergence required for reading (R) is 2 △ to the left of the zone of ocular comfort, so that O. U. 2 △, base out, would be the smallest amount of prism that should alleviate the ocular discomfort, as can be calculated from:

$$\text{Abd.} + 1/3 \text{ R. C.} = -2 + 12/3 = 2.$$

In a case of exophoria at the reading distance, let the data obtained be: Abduction 15 △, adduction 5 △. Then the prismatic assistance to be given on the basis of the area of comfort would be:

$$\text{Add.} - 1/3 \text{ R. C.} = 5 - 20/3 = -2.$$

Hence O. U. 2 △, base in, would be incorporated.

In conclusion, the correction of refractive errors, if of high degree, may cause a profound alteration in the relative activities of the innervations controlling accommodation and convergence. Innervation may be suppressed or inhibited or, again, it may be called into play to a greater degree than previously. Many persons have the ability to adapt themselves to the new conditions set up by the correcting lenses, and temporary inconvenience only is produced. Unless there are evidences of decided incoördination of ocular functions, it is good practice to prescribe lenses correcting only the refractive errors and to omit prismatic corrections except in conditions of vertical imbalance. Subsequent examinations (within a period of a few weeks or a month) should then disclose whether functions are in weakness or strength, as well as the character and amount of the excess or deficit. From a consideration of all the data thus obtained, logical conclusions regarding the necessity of prismatic assistance can be drawn.

Conclusions

1. Conditions of ocular discomfort which have not responded to the correction of refractive errors are encountered frequently.

2. The causes of this ocular discomfort may reside in either accommodative or convergence weakness or insufficiency, or in a combination of both. Or, again, there may be excessive accommodation or overconvergence, or a combination of both.

3. Data should be obtained regarding the relative amplitudes of accommodation and convergence at distant (6 meters) and close (33 cm.) points of fixation as an integral part of every routine refraction.

4. Relative amplitudes and ranges of accommodation and convergence only should be considered, since the absolute range of convergence is not involved primarily.

5. The criterion of Landolt, to the effect that not more than one-third of the absolute range of convergence can be exercised continuously without fatigue, should be questioned.

6. The criterion that not more than one-fourth to one-third of the amplitude of relative convergence can be employed continuously and with comfort, appears to be substantiated by practical experience.

7. The imbalances of the extra-ocular muscles, disclosed by dissociation tests, do not constitute, in and of themselves, sufficient basis for the prescription of prisms.

8. The laws of supply and demand are as applicable in conditions of ocular weakness, whether this be in accommodation or convergence, as in other problems involving elements of weakness and strength. The liabilities must be considered in the light of the reserves which are displayed under test.

9. The conception of a zone of comfort, as portrayed by Percival, is a valuable one in the consideration of the causes and remedies for ocular discomfort.

10. Data regarding the liabilities and reserves of accommodation and convergence can be obtained readily for far and near points of fixation. Deviations from the standard conditions and departures from the zone of comfort may be determined and serve as guides in the prescription of prisms, the giving of stereoscopic and fusional training and treatment, or a combination of both prescribed prisms and innervational training.

11. Prismatic assistance in cases of vertical imbalance is important and should receive careful consideration in all conditions which consistently show an error of 1 prism diopter or more. Hyperphoria should be corrected before making tests on the relative amplitudes of accommodation and convergence.

12. Prisms, base in, are frequently needed, since weakness of convergence is not uncommon.

13. Prisms, base out, are rarely of any value, and should be used ordinarily only as temporary alleviators and until such time as the overconvergence responds to proper suppression of the excessive accommodative innervation, which is probably the cause of the esophoric condition.

14. Many cases which disclose an esophoria at both distant and near test points also exhibit a low positive fusional reserve, and frequently prisms, base in, will relieve the ocular discomfort and aid in the establishment of a satisfactory coördination between convergence and accommodation.

Bibliography

[1] Donders, F. C.: On the anomalies of accommodation and refraction of the eye; with a preliminary essay on physiological dioptrics. London, New Sydenham Society, 1864, 635 pp.

[2] Howe, Lucien: The muscles of the eye. New York, G. P. Putnam's Sons, 1907; Vol. 2, 442 pp.

[3] Landolt, E.: The refraction and acommodation of the eyes and their anomalies. Edinburgh, Y. J. Pentland, 1886, 611 pp.

[4] Maddox, E. E.: Test and studies of the ocular muscles. Philadelphia, Keystone Publishing Company. Ed. 2, 1907, 261 pp.

[5] Maddox, E. E.: The clinical use of prisms. Bristol, John Wright and Company, Ed. 5, 1907, 205 pp.

[6] Percival, A. S.: The relation of convergence to accommodation and its practical bearing. Ophth. Rev. 11:313-328, 1892.

[7] Percival, A. S.: The prescribing of spectacles. New York, William Wood and Company, Ed. 3, 1928, 246 pp.

[8] Savage, G. C.: Ophthalmic myology; systematic treatise on the ocular muscles. Nashville, Ed. 2, 1911, 696 pp.

[9] Sheard, Charles: Dynamic ocular tests. Columbus, Lawrence Publishing Company, 1917, 143 pp.

[10] Sheard, Charles: Dynamic skiametry and other methods of testing the accommodation and convergence of the eyes. Chicago, Cleveland Press, 1920, 108 pp.

[11] Sheard, Charles: On accommodative exophoria, or the acommodation associated with the act of convergence. Am. Jour. Physiol. Optics. 1:234-249, 1920.

[12] Sheard, Charles: Zones of ocular comfort. Am. Jour. Opt. 7:9-25, 1930.

[13] Sheard, Charles: Ocular discomfort and its relief. Eye, Ear, Nose and Throat Monthly, 10:235-240, 1931.

[14] Stevens, G. T.: Treatise on motor apparatus of the eyes. Philadelphia, F. A. Davis and Company, 1906, 510 pp.

[15] Weymouth, F. W., Brust, P. R. and Gobar, F. H.: Ocular muscle balance at the reading distance and certain related factors. Am. Jour. Physiol. Optics, 6:184-205, 1925.

Legends

Fig. 1. Curves showing the relations between accommodation and convergence in a person with normal (standard) vision and no ocular discomfort, as indicated by the adequate relative amplitudes of accommodation and convergence. The line PBA gives the relative positive amplitudes of accommodation and the line NOA gives the relative negative amplitudes of accommodation for various meter-angles of convergence, when readings are made on the vertical axis. The curves also give the relative negative and positive amplitudes of convergence for any given fixation distance, when the readings are made on the horizontal axis. D D_1 is the line of equal accommodation and convergence. D D_2 is the line of accommodation and convergence with the balance at the reading point indicative of 1 meter-angle (approximately 6 prism diopters) of accommodative exophoria. The shaded region graphically locates the area of comfort.

Fig. 2. Curves of relative accommodation and convergence in the case of a person having excessive divergence (exophoria) and insufficient relative convergence (adduction). The line of equal accommodation and convergence (D D_1) lies to the right of the area of comfort.

Fig. 3. Chart outlining the fields of accommodation and convergence, with data which show the relative ranges of accommodation and convergence for points of fixation at 6 meters and 33 cm. from a normal (standard) pair of eyes. The significance of the symbols is:

O = Center of coördinates; also negative relative accommodation at 6 meters.

A_F = Positive accommodation (minus lens) at 6 meters.
A_P = Positive accommodation (minus lens) at 33 cm.
A_N = Negative accommodation (plus lens) at 33 cm.
N_F = Divergence or abduction (prisms, base in) at 6 meters.
N_R = Divergence or abduction (prisms, base in) at 33 cm.
C_F = Convergence or adduction (prisms, base out) at 6 meters.
C_R = Convergence or adduction (prisms, base out) at 33 cm.
O_{D1} = Line of equal accommodation and convergence.
O_{D2} = Line of accommodation and convergence with the balance at the reading point indicative of 1 meter-angle (6 prism diopters) of accommodative exophoria.

$O_{D2}Z_2Z_1$ = Area of comfort.

ASTIGMATIC ACCOMMODATION*

B. M. Lazich, B.Sc.,A.O.
Buffalo, New York

In a significant percentage of cases, a variability of astigmatism between near point and far point has been noted with increasing inquiry as to its source. This so-called dynamic lenticular astigmatism, or astigmatic accommodation, has been the object of various researches since Dobrowolski first expressed the idea in 1885. Subsequent writers have both emphatically advocated and denied the existence of such a phenomenon, each postulating theories to support their views.

That such changes in astigmatic refraction of the eye accompanies different degrees of accommodative action has become more evident with the incorporation of dynamic skiametry into the routine of ocular refraction. Caution must be exercised in the interpretation of findings, especially the apparent increase or decrease of cylinder between static and dynamic retinescopic findings. It must be evident that if the axis of the corneal astigmatism is minus 180° and that of the crystalline lens minus at 90°, an increase of lenticular astigmatism would in actuality seem to be an ocular decrease at 180°. Confusing factors are oblique cylinders (which resolve into resultant cylinders) and lens effectivity. In the latter instance an increase of plus background tends to reduce the total cylindrical component.

The proponents of astigmatic accommodation state that the crystalline lens compensates for astigmatic defects by an equal but opposite defect (cross cylinder effect) brought about by unequal accommodation in the different meridians of the crystalline. Thus, they say, the crystalline lens is capable of being deformed unequally and in such a manner as to eliminate as much as possible the distorted images of astigmatism. Chief evidences in support of this view have been cyclopegic findings, subjective variations with and without fogging techniques, and various other minor factors.

Whether or not such conpensatory power is possible, changes in astigmatism from static to dynamic, have and are being found. The variance between 6 meters and say 33 cm. is never very great. Sheard

*Submitted for publication August 3, 1934.

(A. J. P. O.—1926), employing subjective skiascopy with monochromatic light, found the greatest increase within 1½ feet, and at one foot found .62 D. change. Routine clinical precedure gives findings of not more than .25—.50 diopters difference between static and dynamic, the latter being taken usually at 50 cm. It must be remembered that there are many cases wherein no change whatever is found. Let us also emphasize the fact that in clinical procedure the correcting cylinder is placed in the phoropter, the actual ocular astigmatism being considerably less than the indicated correcting lens. The change therefore is never very great.

In spite of the fifty years the phenomena has been known to exist, the explanations are still not very conclusive. The postulate most generally accepted now, is that originating from the experimental work of Hensen & Völkers (1868-78). that is: unequal stimulation and contraction of the ciliary body results in unequal deformity of the crystalline lens in the various meridians. This has subsequently been denied by eminent physiologists, who maintain that all the evidence goes to show that in life, the ciliary contracts, not in part, but as a whole. Despite this contradition many still hold to the original theory.

The writer, however, believes that if the significance of the following is understood there is no necessity for propounding any such contra-physiological theory. So before making any further statements we present this following review of factors producing ocular astigmatism so that we may better understand the perplexing variable—dynamic astigmatism.

Astigmatism of refraction arises both from differences in principal curvatures of a given surface and from the obliquity of the incident rays upon that surface. Following are the refracting surfaces of the eye:

(a) Anterior Corneal Surface—The curvatures are easily and accurately measured by means of the ophthalmometer. Inasmuch as the difference in indices of air and the cornea is comparatively high a small variation of principle curvature gives a relatively high astigmatic value. It is at this surface, then, that the major portion of total ocular astigmatism originates.

In the majority of cases (80-90 per cent) the meridian of greatest refraction is vertical, causing an astigmatism with the rule; as high as .50-.75 diopters being considered physiological.

(b) Posterior Corneal Surface—The curvatures are rather difficult to measure and are entirely neglected in ordinary clinical procedure. There is ample reason to believe that inequalities and consequent astigmatism do exist but the small change of index from cornea to aqueous reduces the importance of a defect to five or six times less than a similar toroid on the anterior surface. To lose sight of it entirely would also be fallacious for even as we find high anterior surface findings we may similarly occassionally expect to find comparatively higher posterior findings,

according to statistical distribution of all physiological and anatomical structures. This astigmatism is usually against the rule.

(c) Lens Surfaces—Small differences in curvatures have been found by various investigators but, here again the similarity of index values tends to obviate or reduce their importance to negligibility. A problem of this sort is difficult to approach, because even present day methods of measurement are not exact.

(d) Astigmatism due to Obliquity—The optic axis is the hypothetical axis about which the spherical surfaces of the eye are supposed to be centered. Strictly speaking there is true axis of symetry, but still and all, a rather close approach to one, the conception of which greatly aids in the study of the eye as an optical instrument. Be that as it may the axis of the lens does not coincide with this optic axis and the lens is therefore not concentrically arranged in respect to the rest of the system The deviation of the lens is mainly about its vertical axis, the temporal edge being more anterior than the nasal, to an amount estimated at from 3°-7°. A slight tilt is evident in the horizontal axis also, the top edge being inclined slightly forward. Moreover, the fovea is eccentrically placed in regard to the optic axis. Detailed measurements are, of course, extremely difficult to make. The net effect is to create an astigmatism calculated by various writers at between .1 and .75 diopters tending to counteract the physiological corneal astigmatism—i.e., lenticular astigmatism corrected by a minus cylinder axis 90°.

Now, since dynamic astigmatism is a variable, the cause must be a variable. Factors a. b. and c. are constant but factor d. is not. It is this point which the writer wishes to stress for therein lies evidence which as far as we could ascertain, has never been brought forward, never investigated as a potential solution. For, if a certain degree of astigmatism is granted to exist in the crystalline when it is of a certain dioptral power (static—unaccommodated 19.11 D. Gullstrand) that amount of astigmatism must certainly be increased when the crystalline is of a greater dioptral power (say accommodated 33.06 D. Gullstrand). Furthermore we shall expect proportional variations between these maxima and minima. It is as if a certain lens of an optical system were obliquely placed thereby causing a certain given amount of astigmatism. If this lens were then removed and another lens of greater power were inserted in the same position an astigmatism of a greater degree would be produced. Also, if the lens were tilted even more the astigmatism would again be increased. But, the tilt is characteristic of the individual and does not vary whereas, the dioptral power varies according to the point of fixation.

Let us repeat, the physiological lenticular astigmatism is small, the increase in astigmatism when the eye is functioning dynamically is probably still smaller. It is not surprising that in the majority of cases it escapes our crude methods of detection. Stumbling blocks of subjective determination are the psychological factor of discrimination, habit for-

mation and various other human factors. We may also include the unknown quantity of retinal curvature, which tends to conform with the curvature of the image field and thereby reduce distortions. Notwithstanding these factors a significant number of cases present changes which are evident and measureable. This is to be expected, for in the majority of cases the eccentricity of the lens is small with a consequent low physiological lenticular astigmatism, whereas a smaller group presents values which are considerably greater.

If we concede the proposed cause to be true the following corollaries must then exist:

1. Since the lenticular astigmatism increases with the dioptral power of the crystalline we shall expect changes in astigmatism the closer the point of fixation, the greatest change occurring within 33 cm. If. the static lenticular astigmatism is originally minus at 90° we shall get an ocular increase at 90° or decrease at 180°. It has been observed that a small component exists in the horizontal meridian. Although it is highly improbable that the chief tilt of the lens would present itself in this manner, nevertheless, we must consider all possibilities. This latter condition would result in an increase at 180°.

2. Since the astigmatism increases with the obliquity of the crystalline we shall expect individual differences in degrees of dynamic lenticular astigmatism according to statistical physiological distribution.

3. Since the lenticular astigmatism is not very great any factor which acts very strongly to nullify anterior corneal astigmatism must originate from the only logical source—the posterior surface of the cornea.

Summary

1. Variations between static and dynamic astigmatism have been found in a certain percentage of cases, the present explanation of which is untenable.

2. Generally, variations are small, for the most part escaping detection.

3. It is agreed by authorities in physiological optics that the lens is obliquely placed in regard to the optic axis, thereby causing astigmatism against the rule from .1 to .75 D.

4. If we grant the above condition it must be obvious that the astigmatism will be increased when the refractive power of the crystalline is increased.

Conclusions

1. Statement: In the writer's opinion, dynamic lenticular astigmatism is the result of an increase in dioptral power of a crystalline lens of inherent static physiological astigmatism.

2. Significance:

(a) There is the possibility of the prescription of cylindrical corrections specifically for near work. These cases will not be frequent as they represent an extreme physiological lenticular astigmatism.

(b) A more accurate conception of the defects of the optical system of a given pair of eyes is obtained with the knowledge of exact cause and effect relationship. Thus, if the character of each refracting surface is known, case analysis becomes less a matter of trial and error rules but rather a statement of structural facts.

3. Possibilities: The writer feels that before any judgment is passed a more thorough investigation is necessary. Experimental procedure shall lie in the direction of specific study, including:

(a) Precise physical measurements of the optical system—surface curvatures, angle α, deviation of the lens, etc., etc.

(b) The use of monochromatic light in subjective precedure, careful measurements in skiascopic technique and the addition of clinical data provides the rest of the material to be covered.

This work cannot be completed in a day but if well done should prove of tremendous value both in clinical appreciation and as a welcome solution to one of the problems in Physiological Optics. It is for this reason that the writer desires any constructive criticism.

DR. B. M. LAZICH
719 NORTHAMPTON
BUFFALO, NEW YORK

A FIVE OUTLET RHEOSTAT*

F. McFadden, Opt.D
Rutland, Vermont

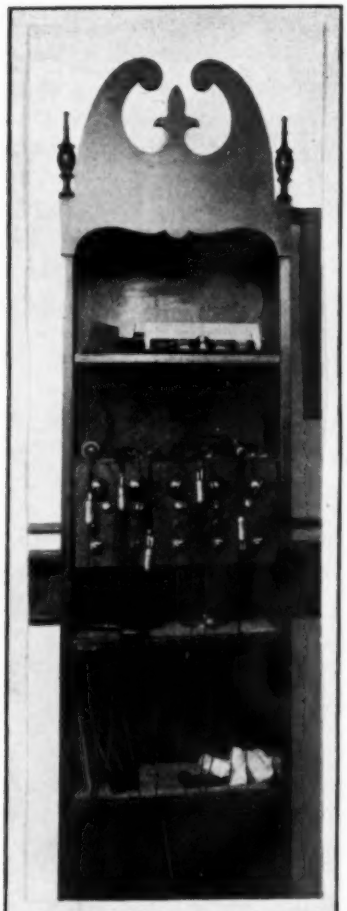
The arnamentum of the well equipped optometric office today calls for several hand instruments, the ophthalmoscope, hand slit lamp, trans-illuminator, dynamic skiascope, static skiascope, and possibly the oto-scope. While we would like to take space and time in describing why the otoscope is highly useful as an optometric instrument, we shall leave this subject for some future discourse. Likewise, we shall briefly dismiss discussion of the definite difference in the dynamic skiascope and its static brother, by saying that they are somewhat similar, but yet quite different.

A considerable number of offices are now equipped with commercial rheostats, some of which have only one pair of out-put terminals, the voltage being controlled by a knob and graduated dial. There is on the market, so far as the writer knows, only one three out-put rheostat. The inconvenience of disconnecting the hand instrument from its terminal, then hooking up another for use, finally in many instances being compelled to repeat these changes from two to six times per patient, is at least an inconvenience and a distraction. But a distinctly greater annoyance is the fact that each instrument should have a different voltage for its best effective illumination. Now, when the ophthalmoscope calls for twice the output which the filament of the skiascope or some other instrument can possibly stand, the result is a burned-out instrument lamp, the cost of which is $1.25 or more, and its replacement is usually several days and hundreds of miles distant. The mere necessity of constantly turning-up or turning-down current for illumination needed, not to say the distraction from intricate work upon a fundus, by constantly worrying whether or not we have reduced the current to safety-limits, is unpleasant.

The circuit to be described is in no measure novel, or patentable, but is an extension of well known wiring patterns which can be carried out by your own local radio man who can readily follow the description and graphic representations accompanying.

Power from the line comes in at about 110 or 120 volts. This is connected to a bell-ringing transformer (A in Fig. 4), of which there

*Submitted for publication August 10, 1934.



Dr F. McFadden
Figure 1.

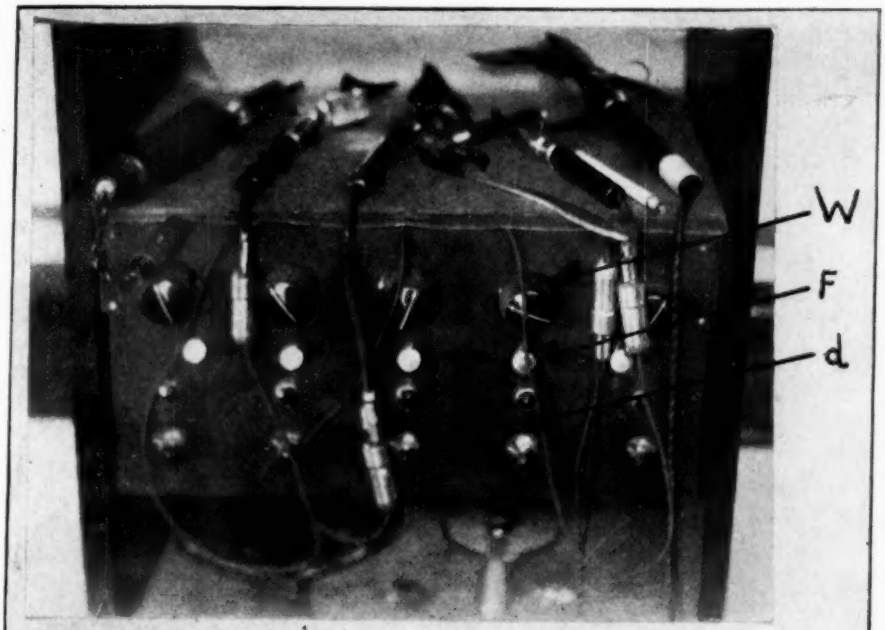
is a large assortment upon the market. The one used by the writer has seemed the more satisfactory, because it has three possible power outputs, 6, 12, and 18 volts, dependent upon how the terminals are connected. While our hand instruments are rated at from 3 to 6 volts, it might be supposed that a simple transformer of that value output would suffice, but because there is considerable resistance to our cords, and pilot lamps to be later described, it is well to have a 12 volt output, while on other occasions an even higher output of 18 may be required for some of our future instruments.

In the drawing shown (Fig. 4), the take-off from the transformer A is led to a supplementary distribution panel at the back of the apparatus, as shown on the chart at B. From this back panel, a lead runs from each plug to the input terminal of each of the five rheostats, shown graphically with the zig-zag lines arranged in a circle (at C, Fig. 4). The arrow-point inside these circles represents the movable contact of the rheostat knob in the center of Fig. 2, where this knob rotates clockwise to increase illumination of the hand instrument.

From this central terminal of the rheostat (C, Fig. 4), one wire d is carried to a set of terminals having two sockets, into which the tips of the cords e of the hand instrument are inserted.

There are of course two wires to these socket, d, d^1, one of which is the wire mentioned, d, while the other comes directly from the central terminal of the Transformer, h. It will be understood by the wiring expert that the first lead-wire described runs continuously along the supplementary panel, b, being connected to each of the out-put terminals of that board, 1, 2, 3, 4, 5, while the last-mentioned transformer terminal also runs consecutively to the five instrument terminals, d^1, d^2, d^3, d^4, d^5.

Along the bottom of this front board, a hard rubber plate, which we call the switch panel, is a row of five knobs, k, l, m, n, o, which turn on or turn off the light of the individual hand instruments. This little radio device is so constructed that its socket, behind the panel, holds

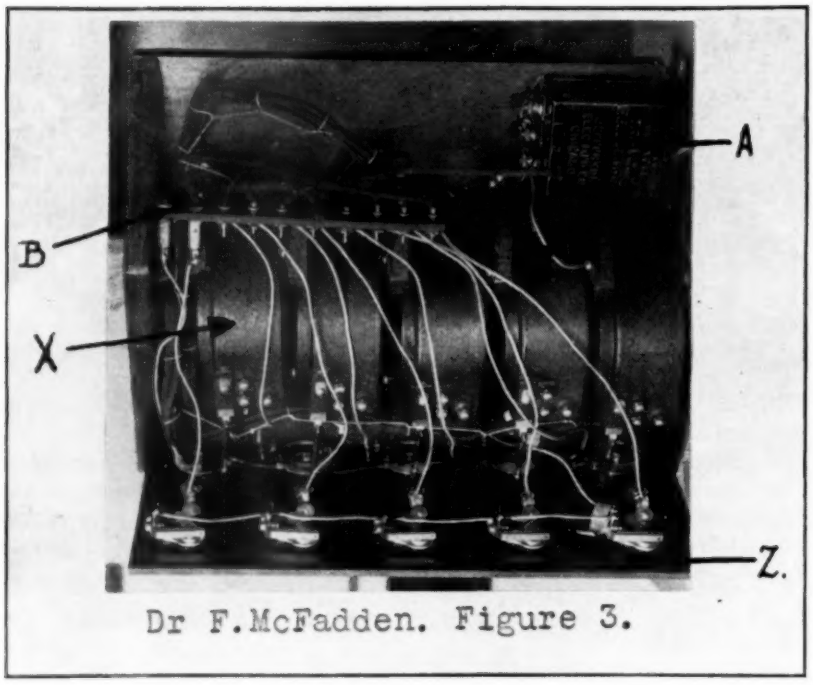


Dr F.McFadden. Figure 2.

a flash-lamp bulb of about 6.2 voltage. These are the pilot lights which serve in several capacities. When the light is ON in the hand instrument this lamp glows, shining through a "jewel" before a hole in the panel. These jewels come in green or red, and are a warning that our instrument is burning, which largely obviates the risk of its being left on for a long period, as over night, and the like. Our instrument bulbs deteriorate fast enough with their hours of actual service, and should not be injured by abuse.

But this pilot bulb is selected of just sufficient voltage to be burned out *before* our instrument bulb could have been raised to too high a power. We wish to be able to turn "up" the rheostat C to full illumination of the capacity of the skiascope, ophthalmoscope, or whatever, but not to a destructive height, and the pilot bulb, costing 5c to 6c acts not unlike the fuses in our house wiring, thereby saving the $1.25 instrument bulb. This pilot light may be different in the several circuits, and the outfit your wiring man may build may not require exactly the 6.2 volt light mentioned.

In the apparatus pictured (Fig. 3-X), you will observe five rather large cylindrical parts. Now these are entirely optional, serving as a convenience, but which are now not so readily obtainable as when this was built. They are automatic winders, such as are used on automobiles with the smoking device, having a long cord which pulls out several feet, and

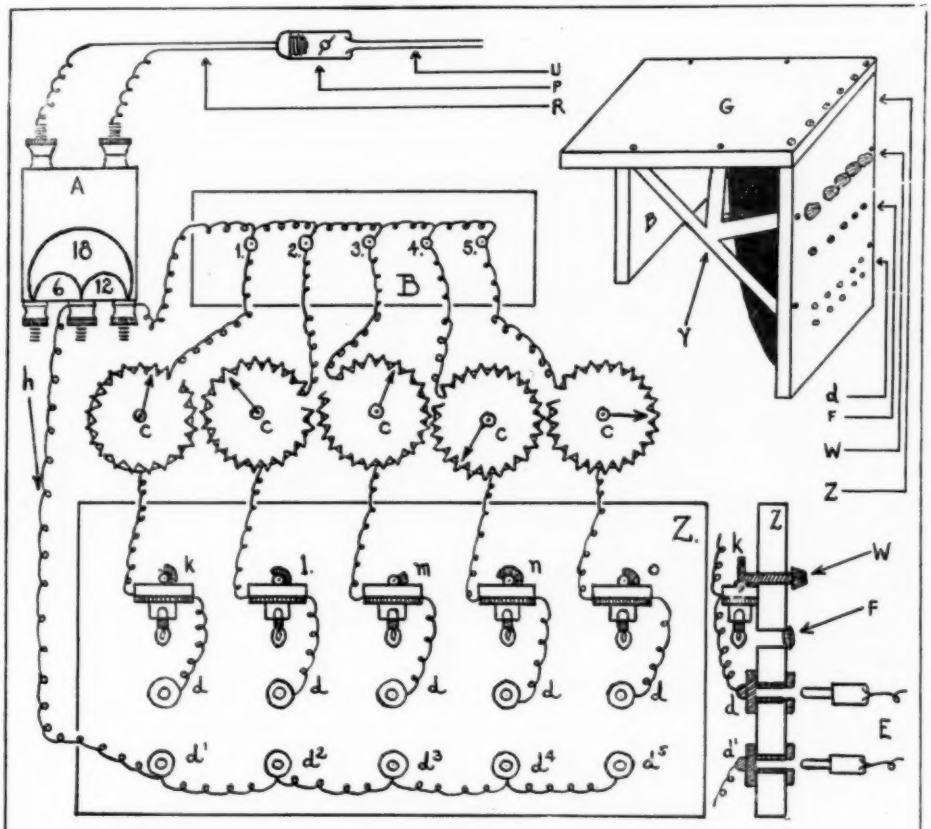


Dr F.McFadden. Figure 3.

rewinds upon a spring controlled barrel. I suggest omitting these, for obvious reasons. Without them, the interior of the apparatus looks much simpler, and it somewhat reduces the complications. The cords of the instruments themselves are usually sufficiently long, and they may hang down in loops before the cabinet, the picture showing them thus, which considerably reduces the cost, by omitting these winders.

The apparatus is put together as a shelf of wood, upon which is rigidly mounted the transformer, A, the back-panel, B, and to which is screwed the black rubber front-panel, Z. A brace-piece, y, between the shelf and panel makes all rigidly secure. The rheostat knob, the pilot and switch, are now all that are *necessary* to this front panel, omitting the rewinding convenience, controlled by the five w knobs. There is nothing to get out of order in the apparatus, and it will function for many years without attention, other than the possible burning out of the pilot light. This is easily replaceable without removing the panel from the cabinet. Merely reach under the panel and replace the burned out bulb with another of like voltage.

The board is the "base" upon which the heavier portions of the compound rheostat are mounted, and being inverted it is also the shelf upon which to lay in appropriate order the several hand instruments. This board may be covered in any appropriate manner, either with a clean white napkin, white paper, or velvet pad. If the several instru-



Dr F. McFadden. Figure 4.

A = Bell Transformer.
B = supplimentary distribution panel.
C = rheostats.
d = jacks for instrument tips.
E = instrument tips.
F = jewels.
G = wooden shelf.
h = cord from transformer.
k,l,m,n, & o = Lights.
P = key socket.
R = cord to bell transformer.
U = rubber cable to base plug.
W = rheostat control knobs.
Y = brackets.
Z = solid black rubber front panel.

T.O.B.

ments are layed upon a clean and often renewed white surface they will make a very pleasing appearance.

We really should make these several expensive hand instruments reasonably conspicuous, and in doing this, it is sensible to secure an impressive cabinet of suitable designs and proportions, built of such material, and finished in such a manner as to correspond with our other instruments and woodwork. The one shown is that of a popular small book case. Avoid anything "boxy" that must stand upon something

else, or be inconveniently or inconspicuously placed. Rather, secure a cabinet which stands by itself, and in such position, relative to other instruments, that it cannot help being seen.

In use, we have but to select the ophthalmoscope, turn the switch which causes its red jewel to glow from its interior pilot light, and proceed with the examination. If, for reason, more or less light is required, we merely turn the rheostat knob accordingly. We lay back this instrument, picking up the hand slit lamp, lighting and intensifying, accordingly. Next comes the transvisualiser, into which we may on some occasions find it expedient to change the lamp to that of the sinus or dental tubes, which require some adjustments. This instrument is layed back, its light extinguished, after which we may perhaps desire the otoscope in some corneal examination, or the like. The static skiascope is next brought into service, which may in one case require considerable illumination and in others allow only a low degree. This is regulated by the appropriate rheostat directly above its output terminals.

Some optometrists may be desirous of having instantly available the streak skiascope and another with the flat light. With the fifth outlet these may be instantly selected at will, each with proper illumination. The writer prefers a static skiascope distinct from the one used for dynamic work, the latter having some fixation charts and devices attached to its stocks. At any rate, five output terminals are none too many, and if there were two or three more, they would only add immeasurably to convenience without increasing the cost appreciably.

Having the apparatus arranged beneath a shelf, as illustrated, obviates accumulation of dust, which merely settles upon the frequently renewed instrument pad. The mechanical and wiring portion is wholly concealed, only the glowing jewels and radio knobs being conspicuous and intriguing. The other shelves of the cabinet are utilized for two different types of pupillary gauges, hand mirrors, reading-chart booklets, and similar necessities.

The cost of the instrument, aside from the cabinet, should not exceed $35 or $40, allowing liberally for all work and materials, while the cabinet itself does not necessarily call for any considerable outlay. The one pictured was retailed at $18.00. Omitting the several advantages of no-burn-outs in the several instruments, the convenience of picking out and laying aside the several instruments in rotation, their safety against falling, and the like, the psychological value itself makes the whole ensemble worth from $100 to $200. It is indeed regrettable that some of the instrument makers of optometric apparatus cannot be sufficiently impressed with the advantages of so completely equipped and assembled an appointment as this, so that it might be marketed.

DR. F. McFADDEN
MEAD BUILDING
RUTLAND, VERMONT

THE CLINICAL SIGNIFICANCE OF DIFFERENCES IN THE RELATIVE SIZE AND SHAPE OF OCULAR IMAGES*

Howard C. Doane, Opt. D., F. A. A. O.
Boston, Mass.

We, as optometrists, are concerned primarily in the welfare of the individual and our task is to provide not only good vision but comfortable binocular vision.

Therefore, on the above premise, we are charged with the solution of problems that call for an understanding of ocular conditions which affect the maintenance of simultaneous, binocular vision; an understanding of all factors involved in the function of binocular vision.

It is not my purpose to enter into a discussion of theories pertaining to this subject but rather to make a concise presentation of my understanding of binocular vision and to bring to you the results of my clinical experience in measuring and correcting "Aniseikonia," which has not, until recently, been considered a factor in this all important function.

Binocular vision being one of the commonest experiences of our daily life, we are not directly aware of its complex functioning, although its reality can be demonstrated by its effects. We are unconscious of the existence of two fields of view, one contributed by each eye. We may experimentally produce double images yet it is impossible to tell by introspection to which eye the images correspond.

From a practical standpoint, it is impossible to build up a concept of binocular vision by examining just the monocular fields and additively combining the results obtained. In order to arrive at a concept of binocular vision, we must consider in addition to the observable monocular phenomena, the existence and relations of the two retinal images from which the ocular images are derived and the relations and laws of the binocular movements of the two eyes.

Since the two eyes must function together for efficient binocular vision, the two images of the object gazed upon are of primary importance. Now, the distribution pattern of the retinal elements of the

*An abridgement of the material presented before the American Academy of Optometry at Baltimore, December 18, 1933.

retinas upon which the dioptric images are formed are not identical and may change independently with movements of the eyes, *e. g.*, as in convergence. Furthermore, the dioptric centers of the eyes in general are not the physiological centers. Thus, the size and shape of the ocular images, which are determined by the properties of the dioptric images and the modifications imposed upon them by the anatomical and physiological processes of the visual system, may be quite complex. However, these ocular images must be combined in the higher cortical centers for binocular vision.

Corresponding retinal points are points which function through the same brain centers and are found by experiment to combine their images when simultaneously stimulated. According to Ames, Ogle and Gliddon: "Every point on the retina of one eye has a primary nerve connection to a specific brain center to which a specific retinal point in the other eye is similarly connected." They further state, that: "The stimulation of either one or both of a pair of corresponding retinal points excites the same brain center and produces one subjective directional value; that the stimulation of two pairs of corresponding retinal points excites two brain centers and produced a definite subjective directional separation value; while the stimulation of three pairs and hence three brain centers, gives a subjective impression of two separations whose subjective magnitudes can be differentiated. It is on these relationships that the empirical determinations of retinal correspondence are based."

When the eyes are used binocularly, the images of the fixation point must be fused. These images will or will not fall on corresponding elements, depending upon whether a fixation disparity exists or not. They must, however, fall within fusional areas. If, now, we make optical projections of all other pairs of corresponding retinal points, the locus of their intersections in space will, in general, determine a surface. The images in the two eyes of any point on this surface will fall on corresponding points. This surface is known as the *horopter*, and its shape and position in space is an accurate measure of the relative size and shape of the ocular images of the two eyes. The intersection of this surface and the visual plane is a line known as the *longitudinal horopter*, and, as such, is more easily determined experimentally. The longitudinal horoptor lies in the so-called Vieth-Muller circle when the projection fans of the corresponding retinal elements of the same size and their lines are identically arranged. Experimentally the longitudinal horopter lies more nearly in the frontal plane than in the Vieth-Muller circle. This indicates an asymmetrical distortion between the ocular images. The position of the longitudinal horopter is an accurate measure of the difference in the size of the ocular images.

According to earlier theories of binocular vision, all points not on the horopter are seen double, except those lying close to the point of regard in any direction. The images of the latter are formed near the centers of the two retinas and hence are interpreted as single by the mind. The researches of Ames, Ogle and Gliddon have explained the

fusion of such disparate images on the basis of an hypothesis that there are corresponding fusional areas around each pair of corresponding points.

Within limits, then, objects which are not on the horopter are seen singly but they are interpreted as being closer to the eyes or further away than the fixation point. The existence of these fusional areas is supported by three facts (according to Dartmouth): (1) "Our ability to fuse stereoscopic pictures that fall on non-corresponding points"; (2) "Our capacity to keep fused horizontal diameters that are rotated in a cyclotorsional direction through a number of degrees"; and (3) "Our ability to fuse so that they appear as one, rectangles varying in their horizontal lengths." (Ames & Gliddon, "Ocular Measurements.")

According to Adler, "Binocular vision may be defined as the co-ordinated use of the two eyes so as to produce a single mental impression."

The advantages of binocular vision, therefore, are obvious:

1. Optical defects present in one eye are made less important by being covered up by the normal vision of the other eye.

2. Defective vision in any part of one visual field is masked for the same reason.

3. The binocular visual field is larger than either field alone.

4. Stereoscopic vision or depth perception is acquired.

The requirements for binocular vision may be cited as follows:

1. No pathology such as (a) cloudy media, (b) impaired retina, (c) lesion of nerve tracts, (d) disease affecting the visual centers of the brain.

2. Sharply defined macula image.

3. Normal use of accommodation in emmetropia or corrected ametropia (Dartmouth).

4. Visual axes directed to the point of fixation (Dartmouth).

5. Fusional amplitudes sufficient to maintain the required vergence (Dartmouth).

6. Approximately similar images must be formed on each retina. If this does not occur there will be antagonism (Adler).

7. The retinae must possess physiologically corresponding points in each macula in order that similar images formed on them may produce one impression (Adler).

In our efforts to produce comfortable binocular vision, we have given considerable attention to all of the factors above stated except those relating to "similar images" and to "corresponding retinal points." It is to these factors that Ames, Gliddon and Ogle have given years of painstaking investigation with the result that these factors are given their proper importance.

We have given particular attention to the careful correction of

ametropia, the correction or treatment of imbalances of the extrinsic muscles, the balancing of the relation of accommodation and convergence and the reduction of amblyopia ex-anopsia by correction or training.

It has been your experience, as well as mine, that notwithstanding the fact that with careful attention and correction of these factors, the ocular troubles of many patients were not relieved. No reasons for continued discomfort were evident and those cases were classed as ocular neuroses. If, however, those factors affecting the relative size and shape of ocular images had been considered, a logical cause for the trouble is seen. With a difference in the relative size and shape of ocular images, the brain has the task of matching two images of unequal size, thus imposing a strain on the fusion centers. It has been definitely found that slight differences in the size of ocular images result in false binocular sterescopic vision.

It has been my good fortune to have had contact with the research at Dartmouth, for several years and have followed the work carefully. I fully appreciate the honor and responsibility of being the first to apply in office practice the results of the work of this group of scientists.

You have read the scientific papers of Ames, Gliddon and Ogle and the clinical reports of Drs. Carleton and Madigan. You have listened to a clear exposition of the works of these gentlemen by Dr. Neumueller and I assume you are now anxious to hear particularly of the application of these theories in actual practice. This report will differ in one respect from the clinical report of Drs. Carleton and Madigan, in that their work covered referred cases principally, while this report covers those cases presented in regular office practice.

It might be well here to give certain new nomenclature, quote the definitions and emphasize certain terms.

Ocular Image—The ocular image is the *visual impression* produced in the brain by one of the eyes. Its form is determined both by the characteristics of the dioptric image formed on the retina and the characteristic distribution of corresponding nerve points in the retinal structure. Reference then to "Image Size" should be understood to mean the size of the ocular image and not that of the retinal image.

Iseikonia is that condition where the relative size and shape of the ocular images are equal and symmetrical.

Aniseikonia is that condition where the relative size and shape of the ocular images are unequal or asymmetrical.

Megaleikonia refers to the larger of the two images as R-Megaleikonic 2%.

Micreikonic refers to the smaller of the two images as L-Micreikonic 2%.

Iseikonic lenses are lenses designed to correct a condition of Aniseikonia.

Aniseikonia may be of various types and are classified as follows:

A—Overall—where one ocular image is larger than the other in all meridians.

B—Meridional—where one ocular image is larger than the other in one meridian only.

C—Compound—where the difference may be various combinations of overall and meridional.

Ophthalmo-Eikonometer—An instrument designed and used for measuring the relative size and shape of ocular images.

My approach to this work was with an open mind. I wanted answers to the questions which we have all pondered. How prevalent is Aniseikonia? Does the correction of Aniseikonia relieve symptoms which persist after other factors have been taken care of? Does Aniseikonia exist without causing discomfort? What type of symptoms usually accompany Aniseikonia? What type of cases usually show Aniseikonia? Does the correction of Aniseikonia change the character or alter the amount of the 'phorias? Does this anomaly exist in emmetropic cases?

In presenting the data I have acquired since May of this year, when the ophthalmo-eikonometer was installed, I shall proceed from three angles. First, a record of the number of cases examined, giving the prevalence and types of Aniseikonia found, the types of cases in which most frequently found. Second, to classify the cases according to symptoms and third, the clinical effect of the correction of Aniseikonia.

In routine practice, it has been impossible to make complete examination in every case on account of the time element but my procedure has been to follow regular routine, first eliminating pathology, then determining refraction objectively and subjectively with an analysis of 'phorias and fusional reserves at 20 feet and 40 cm. A determination was then made as to the existence of Aniseikonia. If the history and symptoms warranted, a second appointment was given, when a thorough analysis of the Aniseikonia was made.

Approximately three hundred cases were examined on the above basis. Two hundred and twenty demonstrated size differences. This indicates that 73% of those presenting themselves for examination on account of ocular or general symptoms have a demonstrable amount of Aniseikonia.

Out of this number, complete analysis was made on eighty cases and it is on this group that the report following is based. The reason for not completing the analysis of the remaining cases showing Aniseikonia was because discomfort and symptoms did not warrant it or because of the expense involved.

Of the eighty cases examined, fifty-three have been given correction for Aniseikonia. Of this number, forty-two were meridional, seven were overall, four were combination of overall and meridional, sixteen

were given temporary correction for refraction and to be again examined. Eleven were found to have wide tolerance for size difference and correction for this seemed unnecessary.

Of the fifty-three cases given correction, thirty-five report definite relief; two report partial relief; seven report no relief; nine have not reported.

The following tables have been prepared to give a graphic picture of the types of Aniseikonia found, the types of refractive errors and muscular anomalies in which most frequently found, classification according to symptoms and clinical effect of correction of Aniseikonia.

TABLE 1
Types of Aniseikonia
80 Cases

Meridional	51
Overall	20
Meridional-Overall	9

TABLE 2
Correction given
53 Cases

Type—Meridional	42
Overall	7
Meridional-Overall	4

TABLE 3
Correction not given
27 Cases

Reason—Analysis not complete	16
Wide tolerance	11

TABLE 4
Age of Patients

Age of youngest patient	13
Age of oldest patient	64
Average age (80 cases)	34.5

TABLE 5
Refractive Conditions with Aniseikonia
80 Cases

Emmetropia	2
Ametropia R and L equal refraction	7

Anisometropia					
Hyperopia	.25	to .50 D	diff.	13
"	.62	" 1.00 D	"	2
"	1.12	" 2.00 D	"	2
"	over	2.00 D	"	1
Myopia	.25	" .50 D	"	4
"	.62	" 1.00 D	"	3
"	1.12	" 2.00 D	"	1
"	over	2.00 D	"	1
* Hyperopic Astigmia	.25	" .50 D	"	16
"	.62	" 1.00 D	"	8
"	1.12	" 2.00 D	"	2
"	over	2.00 D	"	1
* Myopic Astigmia	.25	" .50 D	"	10
"	.62	" 1.00 D	"	4
"	1.12	" 2.00 D	"	1
"	over	2.00 D	"	2

*Includes simple and compound.

TABLE 6

Phoria—80 Cases

Condition	Number	1.50Δ or less at 20 ft.	5Δ or less at 16 in.	Average Phoria 20 ft.	Average Phoria 16 in.	Largest Phoria 20 ft.	Largest Phoria 16 in.
Orthophoria	6	----	----	-------	----	-----	-----
Exophoria	43	36	32	1.70Δ	6Δ	10Δ	16Δ
Esophoria	33	29	5	1.33Δ	3Δ	6Δ	10Δ
Hyperphoria	20	18	----	.50Δ	----	4Δ	----
Cyclophoria	4	Amount not measured.					

There is definite evidence that 'phorias with relation to distance and near change with Aniseikonic correction. Some cases showing orthophoria or exophoria at 20 feet with esophoria at 2.50 D. (Physiologic Esophoria) have exhibited esophoria of lesser amount or exophoria at 2.50 D. with Aniseikonic correction. There have not been a sufficient number of cases of this type to make tabulation.

Further investigation of the effect of Aniseikonia upon 'phorias and fusional reserves will be made.

TABLE 7

Amount of Aniseikonia

80 Cases

Meridional type:

	Vertical	*Horizontal*
.50%	7 Cases	3 Cases
.75%	2 "	2 "
1.00%	4 "	12 "
1.25%	6 "	3 "

1.50%	2 "	3 "	
2.00%	5 "	1 "	
2.50%	0 "	1 "	
	26	25	Total 51

Meridional type—average—60%.
Overall type—range—.75% to 3%.
20 cases—average—1.16%.
The remaining 9 cases were "overall combined with meridional."

TABLE 8

Symptoms—80 Cases

General	Number	Per cent
Headaches	64	80%
Dizziness	18	20.5%
Migraine	4	5%
Nervousness	10	12.5%
Ocular		
Eye Ache	16	20%
Eyes tire at movies	48	60%
Eyes tire in auto or train	24	30%
Eyes tire in reading	64	80%
Vision blurs	48	60%
Photophobia	24	30%
Strained or pulling feeling	32	40%

TABLE 9

Clinical Effect of Correction of Aniseikonia

53 Cases

Relief	*Partial relief*	*No relief*	*Not reported*
35 = 66%	2	7	9

As this report covers work done since May of this year, there has not been sufficient time to determine the permanence of the relief nor the permanence of corrections given.

The following case reports illustrate widely different types:

Case 1:

Miss B. G., age 17; student. V. 20/20 O. U.

History: Health always goods. Fitted to glasses in 1928. Could not wear them.

Symptoms: Occasional headache after study. Excessive lachrymation, photophobia, fatigue at movies. Slow reader; hesitates and falters.

Pathology: Negative. Pupillary reflexes full. Routine objective and subjective tests demonstrated no refractive error. Orthophoric at

20 feet. 1° exophoria at 16 inches. Positive fusional reserve low 13/8. Negative fusional reserve low 15/10.

Examination on ophthalmo-Eikonometer demonstrated Aniseikonia. Image of O. D. larger than O. S. in vertical meridian while in the horizontal meridian the image of O. D. was smaller than O. S.

Following prescription was given for constant wear to produce Iseikonia:

O. D. 1.50% meridional Axis 90
O. S. 50% meridional Axis 180

Patient reports marked improvement in reading ability, verified by parents. Subsequent examination, 'phoria at 16 inches, 4° exophoria. Positive and negative fusional reserves improved.

This case definitely demonstrates Aniseikonia may exist without refractive error and correction gives relief.

Case 2:

Miss B. B., age 18; student. Vision 20/20 O. U.

History: Generally good health. Mother wears glasses. Had been given glasses when in high school. Discarded them because of discomfort. Eyes examined later by ophthalmologist who said trouble was muscular deficiency for which he could not give glasses—prescribed drops.

Symptoms: Eyes water after reading 20 minutes. Often sees double; gets dizzy at movies and both dizzy and nausea after one hour of study. Marked discomfort when reading on train. Frequent occipital headache.

External examination: Slight hyperemia of lids and palpebral conjunctiva. Pupillary reflexes prompt and full. Versions full; p.p. conv. 3 inches.

Ophthalmoscope: No pathology. Physiological cupping O. U.
Habitual 'phoria: 4^{Δ} to 6^{Δ} of exophoria.
Keratometer: Negative.
Static Skiametry: R. + 1.00 D. Sph., L. + 1.00 D. Sph.
Dynamic Skiametry: 16″. R. + 1.50 D. Sph., L. + 2.00 D. Sph.
Dynamic Skiametry: 40″. R. + 1.25 D. Sph., L. + 2.00 D. Sph.
Subjective findings: R. + 0.50 D. Sph., L. + 1.00 D. Sph.
Induced 'phorias: 6^{Δ} exophoria.
True adduction: 8^{Δ}.
Convergence: $18^{\Delta}/6^{\Delta}$.
Divergence: $12^{\Delta}/8^{\Delta}$.
Habitual 'phoria: 16″ = 12^{Δ} exophoria.
Cross Cylinder: Add R. + 0.50 D. Sph., L. + 0.62 D. Sph.
Induced 'phoria: 12^{Δ} exophoria.
Positive fusional reserve: 20/10.
Negative fusional reserve: 28/24.

Examination on ophthalmo-Eikonometer demonstrated Aniseikonia. Image of R. equal to L. in vertical meridian but image of R. smaller than L. in horizontal meridian, requiring meridional 1.50% Axis 90 to equalize.

Following prescription was given for general use, particularly for class room and study:

R. + 0.75 D. Sph. 1.50% meridional axis 90 (Fit-Over).
L. + 1.12 D. Sph.

The Iseikonic lens for the Fit-Over was not obtainable at once so patient was directed to wear the refractive correction for study. This caused great discomfort as had previous glasses. The Iseikonic Fit-Over was finally obtained and placed over R. lens as prescribed. Patient reported immediate relief.

It is very significant to note that simple correction of refraction could not be tolerated on account of high exophoria but when Aniseikonia was corrected, no difficulty was experienced.

Case 3:

Mr. T. J., age 40. Teacher.

History: Referred by optometrist who gave following data: "Various prescriptions had been given over a period of several years but patient was unable to find comfort.

Symptoms: Pain in eyes, fatigue after close work. Relief when glasses are removed:

Rx. R. — 2 .00 D. Sph. ⊃ + 2.50 D. Cyl. Axis 95.
L. — 2.00 D. Sph. ⊃ + 2.00 D. Cyl. Axis 85.

After examination gave following:

Rx. R. — 2.50 D. Sph. ⊃ + 3.25 D. Cyl. Axis 95.
L. — 2.00 D. Sph. ⊃ + 2.25 D. Cyl. Axis 83.

One month later reported no relief: feeling of "looking at nose" with Rx. on.

Following prescription given after re-examination:

Rx. R. — 2.00 D. Sph. ⊃ + 2.75 D. Cyl. Axis 95.
L. — 2.00 D. Sph. ⊃ + 2.00 D. Cyl. Axis 80.

Reported ten days later—no relief.

Following prescription given after re-examination:

Rx. R. — 2.25 D. Sph. ⊃ + 3.00 D. Cyl. Axis 95.
L. — 1.25 D. Sph. ⊃ + 2.00 D. Cyl. Axis 75.

Reported later that same symptoms persisted.

Following prescription given after re-examination:

Rx. R. — 1.62 D. Sph. ⊃ + 2.37 D. Cyl. Axis 85.
L. — 0.75 D. Sph. ⊃ + 1.62 D. Cyl. Axis 75.

Reported this gave no relief. Cannot read—pain over left eye—pulling towards nose.

Thorough examination made both for refraction and Aniseikonia made on ophthalmo-Eikonometer November 18, 1933, demonstrated need of following:

Rx. R. + 1.25 D. Sph. ⊂ — 3.25 D. Cyl. Axis 8.
L. + 0.75 D. Sph. ⊂ — 2.25 D. Cyl. Axis 165.

Iseikonic Fit-Over 2% meridional Axis 90.

Patient reported immediate relief—able to read several hours with comfort. Last report December 16, 1933: Has had no discomfort since last correction made. The significance of this case is that patient was able to wear full correction of astigmia after Aniseikonia was corrected.

Conclusion:

The foregoing report gives data that confirms the clinical experience of Drs. Madigan and Carleton, as given in their report, "Annals of the Distinguished Service Foundation in Optometry, 1932," that the existence of Aniseikonia may be the cause of ocular and general symptoms, that the correction of Aniseikonia has afforded definite relief in a large percentage of corrected cases, that the prevalence of this condition and its relation to visual comfort is greater than is generally realized.

It would seem, therefore, that the detection, measurement and correction of Aniseikonia is necessary if all disturbing factors to the maintenance of comfortable fusion and simultaneous binocular vision are to be eliminated.

DR. HOWARD C. DOANE,
59 TEMPLE PLACE,
BOSTON, MASS.

AMERICAN JOURNAL OF OPTOMETRY

Vol. 11 OCTOBER, 1934 No. 10

EDITORS

DR. CAREL C. KOCH
1501 Foshay Tower
821 Marquette Avenue
Minneapolis, Minn.

DR. JACK I. KURTZ
1501 Foshay Tower
821 Marquette Avenue
Minneapolis, Minn.

Original papers, scientific communications, clinical reports, society proceedings, books for review, and correspondence should be sent to the Editor, Dr. Carel C. Koch.

Annual Subscription, $4.00 in Advance, Canada and Foreign, $5.00.
Single Copies, 40c.

Copy of advertisements must be sent in by the tenth of the month preceding their appearance. Subscriptions, applications for single copies, communications with reference to advertising or other business should be addressed to the Business Manager, Dr. Jack I. Kurtz, 1501 Foshay Tower, Minneapolis, Minn.

Published Monthly by the
American Journal of Optometry Publishing Association.

The Journal has no objection to the reprinting by other magazines of any of its articles, provided such reprints are properly credited to the Amerian Journal of Optometry.

HYGIENE OF ILLUMINATION

Hygiene of Illumination is the title of a lecture delivered by Prof. M. A. Tinker before the Minnesota Academy of Optometry's Graduate Course given at the University of Minnesota, during the month of September.

Professor Tinker is the head of the Visual Psychology Department and the data he used in his discussion were derived from research work done at the University of Minnesota Psychological Laboratories as well as other laboratories.

Professor Tinker contends that the three aspects of illumination considered in relation to the hygiene of reading are intensity, wave-length and distribution of light. When discrimination of fine detail is required in reading, a minimum intensity of about 10 foot-candles is essential. In ordinary reading, however, a wide range of intensities may be employed without discomfort or fatigue, although the speed of reading may become less at the lower intensities. If distribution is adequate, reading may be safely done under illuminations of from 3 to 40 foot-candles. In most situations where the illumination is semi-indirect or direct, a

brightness of 2 to 3 foot-candles is better than higher intensities. With highly diffused light as in the indirect system, 5 to 8 foot-candles may be considered adequate for ordinary reading. The average reader, however, prefers a somewhat brighter light if it is available.

Professor Tinker emphasized that control of light intensity alone can not produce hygienic illumination. Brightness of the illumination must always to be considered in relation to the condition of the eyes, legibility of the print, and distribution of the light. When the eye has a refractive error, when the reader is old, and when the copy is of less than optimum legibility, the illumination should be made brighter. In all situations where indirect (diffused) lighting is not employed, however, the lighting should be relatively dimmer in order to maintain the most healthful conditions possible for reading. This means that much of our reading should be done in relatively dim light (3 foot-candles) since most lighting is direct or semi-direct. The tendency is to err on the side of too intense illumination.

Where very fine discrimination is required in visual work, a light of relatively homogeneous wave-length yields clearer vision than the mixed wave-lengths in ordinary lighting. Of the monochromatic or colored lights, yellow is best and blue is poorest for fine discrimination. Sunlight, however, is better than any monochromatic light. In practice these findings can not be applied directly to most reading situations for fine discrimination is not required ordinarily in perceiving words. The ordinary artificial illuminants, which have a mixed wave-length, yield as efficient reading as monochromatic light. We do find, however, that sunlight is a more effective illuminant than any color, and also that it is preferred over any artificial light.

Distribution is the most fundamental aspect of hygienic illumination and also the aspect which is least well controlled in artificial lighting. The distribution of illumination is most adequate when the evenness of illumination, the evenness of brightness at the working surface, and the diffusion of the light is at a maximum. The types of light distribution from most to least effective in promoting hygienic functioning of the eye in reading are: diffuse daylight, indirect system, semi-indirect system, and direct system. In the latter two of these systems the effects of lateral illumination become progressively worse as the number of light sources in the field of vision increases. Marked contrasts in surface brightness within the immediate working surface or in peripheral vision should be avoided.

The maintenance of efficient visual functioning, and in some cases the preservation of normal eyesight is conditioned upon illumination which fulfills the minimum requirements of hygienic lighting. Too great emphasis can not be placed upon the proper coördination of intensity and distribution factors in order to achieve the most hygienic illumination possible in any particular situation. J. I. K.

GRADUATE OPTOMETRIC EDUCATION

In an editorial in the June issue of this Journal the writer discussed the importance of Graduate Optometric Education and Research and recommended that the American Optometric Association give due consideration to these problems. In the February issue, Dr. W. H. Glazer very ably discussed the subject of Optometric Education, indeed in most states it is felt that there is a lack of genuine graduate optometric education and no organization, State or National, has so far provided the machinery to fill this long felt need.

Minnesota Academy points the way. In the meantime the Minnesota Academy and the American Journal of Optometry tried to tackle this problem. The Academy and the Journal arranged for a Graduate Course which was given at the University of Minnesota on the 16th, 17th and 18 of September. Lectures were given by a number of practicing optometrists, namely, Drs. Guy DuPlessis, Robert Best, Carel C. Koch, J. I. Kurtz, Geo. C. Jensen, Otis Wolfe of Chicago and Russell Simpson of California. Several members of the University faculty delivered a series of lectures. They are: Prof. M. A. Tinker of the Psychology Department, Prof. Jos. Valasek of the Department of Physics, Prof. E. P. Lyon of the Physiology Department, and Prof. Chas. Sheard of the Mayo Clinic Bio-Physics Department.

A variety of interesting subjects were discussed during the three day sessions, the following topics were covered by the different lecturers: Astigmatic corrections and their effect upon tursion. The diagnosis and treatment of Cataract and Glaucoma. Clinical case interpretation and treatment. The treatment of myopia. Optometric economics. Abnormal psychology from a refractive clinical standpoint. Hygiene of Illumination. Recent findings about visual acuity. The clinical significance of the normal and abnormal pupillary reaction. The analysis and interpretation of data concerning accommodation and convergence. Ocular discomfort and its relief. Glare, its cause and effect. The physiology of visual sensation. Visual fatigue as caused by different sizes of reading type. Near point ocular tests and their clinical value. Disturbance of metabolism and its ocular effect. Several of the lectures enumerated are reports of research work carried out at the University of Minnesota Graduate School.

The Course was attended by a large number of optometrists not only of the state of Minnesota but from a number of neighboring states as well. One optometrist traveled all the way from California state to attend this educational course. The optometrists who attended were so interested in this educational treat that they passed a resolution urging the Minnesota Academy of Optometry to arrange for a similar course next year and to make this an annual institute.

From the success the Academy had both from the standpoint of interest and attendance it would appear that a partial solution to our graduate educational shortcomings may be found at least for the present

in arranging graduate courses along the Minnesota Academy Plan. These should be given in several well located centers throughout the United States, such as Philadelphia, New York, Chicago, Columbus, Ohio, Berkely, California, and other centers having university facilities. The centers having universities with established optometry schools are best fitted for organizing Graduate Courses, but this is not an absolute necessity, because nearly all universities are in a postion to give us what we need most, namely: Physiology, Physics, Psychology, Anatomy, Neurology, etc. As for refractive and clinical work, let each district draw upon its own material. There are unquestionably a number of talented optometrists in each district who are capable of preparing worth-while papers on clinical subjects which will be of interest to the group. This would serve a double purpose: (1) It would tend to develop some of our men and bring out their latent talent which is now lying dormant. (2) These men will be able to teach something of value to their fellow practitioners. We may also be in a position to call on some well-known educators like Drs. Tait, Ryer, Hotaling, Sheard, Feinbloom, Koch, Neumuller and others.

This educational plan may serve for the present as a foundation upon which all those interested in the advancement of optometric education may be able to build in the future a permanent and more elaborate structure.

J. I. K.

* * * * *

OCULAR SYMPTOMS OF EAR AND THROAT INVOLVEMENT

There is a close relationship between the eye and the ear, nose and throat. This was clearly pointed out by W. Irving Pierce, M.D., in a lecture given before the London Optometric Association which was published originally in the English Refractionist. Dr. Pierce claimed that the most important diseased condition of the ear, nose and throat producing eye symptoms is the disease of the various nasal accessory sinuses.

He then dealt with the anatomy of the various sinuses, the antrums, frontal, anterior and posterior ethmoid cells, etc., stressing particularly the anatomical relation between the orbit and the sinuses. Affection of the sinuses may involve the optic, ophthalmic and auxiliary branches of the fifth nerve, the Vidian and any or all of the motor nerves of the eye. This may take place:

(1) By direct extension of the suppurative process from the nasal accessory sinuses.

(2) Through hypoplastic processes in the sphenoid or posterior ethmoid cells, impinging upon the lumen of the foramina through which they pass.

(3) By absorption of toxins directly through the thin walls separating them from the infected sinuses.

(4) From the effect of reflex irritation of diseases and deformities in the nose upon the vaso-motor apparatus which controls the vessels in the orbit, especially those of the uveal tract and anterior pole of the eye.

Any kind of sinus disease which usually arises through extension of inflammation of the nasal mucosa from colds, influenza, etc., may draw the eye into sympathy or any part of the eye or its appendages. In field anomalies such as peripheral contraction, temporal and bi-temporal, and bi-temporal hemianopia the sinuses should be suspect, failing any other ascribable cause. Dull persistent headaches and disturbed vision are often prominent symptoms which cause the patient to seek eye examination.

The lecturer then detailed a case in which extensive uveitis was present with vision 6/20 which cleared in a short time when the antrum was operated upon. In sphenoidal suppuration there may be lachrymation, photophobia, blepharospasm and transitory scotoma, while in inflammation of the athomoids there may occur an acute retrobulbar neuritis. A history of intermittent vision and frontal headaches suggest a possible sinus origin. A number of ocular diseases may be produced reflexly from diseases or deformities in the nose and sinuses, as Retinitis, Cataract, Iritis, Choroiditis, Keratitis and Glaucoma.

Ocular symptoms due to affections of the ear are the result almost always of the intracranial complications of ear disease, and the ocular symptoms may be Ptosis, Motor Anomalies, Keratitis, ocular conditions associated with paralysis of the third nerve, etc. Retinal changes may be due to Meningitis where this occurs with Suppurative Otitis Media, Papilladeoma may be present, and irregular contractions of the visual fields.

Where the intracranial sinuses are involved, the direct communication of the veins and venous sinuses of the ear with the cavernous sinus and ophthalmic veins accounts for the frequency with which eye symptoms accompany lateral sinus thrombosis. In these cases there may be Papilladeoma, Nystagmus, Proptosis, Retinal Haemorrhage, etc.

Convergence insufficiency is frequently seen in chronic infections, and may be a prominent symptom in brain abscess and meningitis.

Affections of the throat, causing eye trouble are not so numerous, but inflammation of the tonsils and the presence of adenoids may be responsible for a number of eye diseases, the lecturer detailing a case of choked disc due to tonsilitis. Retrobulbar Neuritis due to infected tonsils has been reported, and Conjunctivitis, Blepharitis and Keratitis in a child with no other ascribable cause may be the result of adenoids, while chronic contractions of the eye muscles may occur synchronous with contractions of the muscles of the tongue and diaphragm in spasmodic neurosis of the pharynx. J. I. K.